JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

OCTOBER, 1861.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Bridge over the Theiss, and Tubular Foundations. By M. CEZANNE, Engineer des Ponts et Chaussées. Translated by J. BENNETT.

(Continued from page 154.)

A short notice of a Pneumatic Pile Bridge across the Savannah River.

I am indebted to my friend C. C. Martin for the following sketch of his experience in pneumatic pile-driving. After the completion of the Brooklyn Water Works, during which Mr. Martin was connected with me in the construction of the dams and preparation of the ponds of that work, he took charge of the pneumatic pile bridge across the Savannah River, where he prosecuted the work successfully, until interrupted by the war of the Rebellion.

The Savannah River Bridge is to be on the line of the Charleston and Savannah Railroad, about 16 miles from the latter city; when completed, it will consist of six fixed spans, and a swing bridge, with an aggregate length of 900 feet.

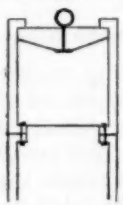
The two abutments and seven piers are to consist of pneumatic piles; the abutments and four piers to be of two piles each; the piers at the end of the swing bridge to consist of four cylinders each, and the pivot pier of five. The cylinders are cast in sections 9 feet in length, and 6 feet outside diameter, with 2 inches thickness of metal;

the lower section of each column is cast or turned with a bevel edge, as shown, in order that it may offer the least possible resistance as it descends; the upper end of this section, and both ends of the others, have a flanch on the inside 3″ wide and 2″ thick, through which are 40 holes 1 inch in diameter, to admit bolts for joining the sections together. The ends of each section were turned in a lathe, so as to be parallel, and thus insure the straightness of the cylinder, though composed of several sections. The cylinders were cast and fitted up by the Trenton Locomotive and Machine Manufacturing Co., of Trenton, N. J., and are certainly monuments of mechanical skill, and do great credit to the manufacturers.

Apparatus.—The apparatus for sinking these piles consists of a large flat boat, upon which is placed a 16 H. P. steam engine, and two double-acting air-pumps; a hoisting apparatus, consisting of a drum driven by the engine, sheer poles, blocks and falls.

The Savannah River at this point has a velocity of about four miles per hour; the tide rises and falls about three feet. The river bottom is composed of clean river sand for a depth of 20 feet, when a strata of coarse clean gravel is found, about 2 feet thick; below this is a stratum of blue material, composed of sand and clay, very compact. The water in the river is always charged with yellow clay, from the interior, so that it is impossible to see beneath the surface; the depth varies from 2 or 3 feet at the shore to 16 feet at the middle.

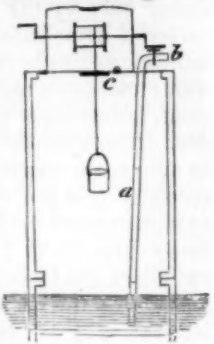
Process of Sinking the Cylinders.—Two sections of cylinder were bolted together, the joint being made air-tight with white lead; both were lifted together and suspended while the "Flat" was being hauled into position by watch tackle running in different directions. When the cylinder was thus brought immediately over the place it was to occupy, it was gradually lowered till the bottom rested on the sand.



These two sections were held in position by guys, while another section was lowered upon them and secured. The sections are hoisted by means of a piece of timber with an eye-bolt, as shown in sketch. The workmen go down in the inside to put in the bolts and secure them, being supported by planks resting on the flanches. A cast iron cap is then secured on the top of the cylinder, and to this is attached a hose connecting with the air-pumps; a large cast iron receiver intervening to receive the water which is pumped out. The pumps being set in motion, the air and a portion of the water in the cylinder is drawn out, and a partial vacuum formed, producing a pressure on the top sufficient to force the cylinder into the sand. In one instance where four sections were bolted together, being in fifteen feet of water, and about four feet in the sand, the cylinder sunk six feet in three minutes on the application of a vacuum. The settlement is generally from one to four feet.

Air-lock.—The next step is to place upon the top of the cylinder an "air-lock," after removing the "vacuum-cap;" this is a section made of boiler iron, arranged with a door in the top and bottom, both

opening downward, large enough to admit a man, and closing air-tight. The air-lock is smaller in diameter than the cylinder, and this allows the insertion of "bull eyes" for admitting light; also a butt and stop-cock. Inside of the air-lock, is a windlass for hoisting material from inside the cylinder. The hose from the air-pumps is now connected with the butt which opens into the inside of the cylinder; the syphon-pipe, *a*, is secured in place, connecting with a stop-cock on the outside of the cylinder on top, at *b*. The bottom door, *c*, is closed, and air is forced into the cylinder by the pumps. The stop-cock is opened, and the water is pressed down by the air above it in the cylinder, and is forced up the syphon-pipe, through the stop-cock, into the open air. As soon as the water is as low as the bottom of the pipe, *a*, men are sent inside to add other sections, and thus lengthen it. The men are admitted as follows: the bottom door being closed, the top one is opened, and men descend into the air-lock, and close the top door; then, by means of a small air-cock in the bottom of the air-lock, the pressure is admitted from below into the air-lock. This closes the top door air-tight, and the pressure in the air-lock becomes equalized with that below, and the bottom door falls by its own weight, and the men descend by means of rope-ladders suspended from the under side of the air-lock bottom. In coming out of the cylinder, the men come into the air-lock and close the bottom door; then, by means of a small air-cock in the side of the air-lock, the pressure is allowed to escape, and the top door falls open.



In allowing the pressure from below to enter the air-lock, great caution is necessary, else exceedingly painful sensations are experienced; different persons are differently affected; nearly all experience a painful sensation in the ears, and some oppression of the lungs, bleeding at the nose, headache, dizziness, &c. As soon as the pipe is lengthened, the stop-cock is again opened, and by a repetition of the process, all the water is forced out of the cylinder, and, by a continuation of the same process, the sand is forced up the syphon-pipe with great force in astonishing quantities; by this means, the sand is all excavated from within the cylinder. A phenomenon scarcely to be expected occurs: on the excavation near the bottom, the air escapes under the bottom of the cylinder, rises through the sand, and escapes in bubbles through the water, in some cases over an area of one hundred feet in diameter; this keeps the water entirely out of the cylinder, and enables the workmen to conduct their operations easily.

Having excavated to the bottom, the men come out, first having removed several lengths of the syphon-pipe, and raised up their ladder, the pressure still continuing. As soon as they are out and all is ready, the stop-cock is opened and the compressed air allowed to escape suddenly; this removes the upward pressure from within, and

the cylinder by its own weight forces itself into the sand, being resisted only by the friction against the sand on the outside, and the material immediately under the lower edge of the cylinder; these are both exceedingly small while the compressed air is escaping, for the water rushes in under the bottom, bringing with it great quantities of sand, which must move with the water down the outside of the cylinder. The cylinder, which sunk six feet by a vacuum, sunk nine feet in about two minutes by allowing the pressure to escape. By a repetition of this process of excavation and "blowing off" pressure, the cylinders were sunk from 25 to 30 feet into the bottom of the river, being from 3 to 7 feet in the hard strata of clay and sand. The cylinders are to be brought up to the grade of the road (about fifteen feet above the surface of the water) by sections cast of the requisite length; they are to be connected together by means of wrought iron ties and braces, and are to have cast iron capitals to receive the chords of the wooden superstructure, which is to be a Howe-truss.

Inclination of Cylinders.—It frequently happens in sinking cylinders that, owing to inequalities in the density in the quality of the material which it penetrates, the cylinder becomes inclined, and it is a very difficult and expensive process to bring it again to the upright position. One cylinder took an inclination of about 8 inches from the perpendicular when it was 25 feet in the sand; the first attempts to straighten it were made upon a very ingenious plan, devised and practised by Capt. William S. Smith, who had charge of the work before I had; it consisted in excavating quite to the bottom of the cylinder, and driving wooden wedges under the lower side, and applying a strain with a tackle purchase. When the pressure was allowed to escape, the cylinder would have a tendency to straighten; these efforts did not succeed, for the cylinder would not move at all.

I then arranged a purchase by which I could exert a strain of at least twelve tons, to pull the cylinder in the direction of perpendicular. The material was excavated to the bottom of the cylinder, and wedges were driven well under the lower side; the excavation was then extended outside of the cylinder on the upper side, so that the air would escape altogether on that side, thus loosening the sand which pressed upon the upper side of the cylinder. In addition to these appliances, I arranged a battering-ram on a small scale, by suspending a stick of timber so that its blows directed against the side near the top of the cylinder should tend to straighten it. Having all things prepared, I took the men out, and allowed the pressure to escape, at the same time "hauling hard" upon the tackle, but the cylinder did not move. I then had the ram brought to bear, and the effect was magical; the thirty tons of metal in the cylinder, under the combined action of the pressure, strain, and ram, yielded readily and was soon brought into position. The slight blows from the ram seemed all that was requisite to loosen the hold of the sand upon the cylinder, and allow it to move.

Incidents and Notes.—The amount of sand that entered the cylinder under the bottom when the pressure was allowed to escape, was

astonishing; on one occasion, when the cylinder had penetrated the sand twenty-one feet, and was nearly through the stratum of coarse gravel, the material having been excavated to the bottom, the pressure was allowed to escape: the cylinder sunk less than a foot, and the sand rose inside the cylinder 22 feet. This quantity = nearly 21 cubic yards, was brought in by the in-rushing water in a very few minutes.

During the process of sinking a cylinder 27 feet, there was the incredible amount of 129 feet in depth of sand excavated.

In several instances, 24 feet (in depth) of water was blown out of the cylinder; in ten minutes, 38,468 lbs. of water, were raised to an average height of 22 feet in ten minutes; and on one occasion, in one hour, we forced out through the syphon-pipe 15 feet in depth of sand, equal nearly 14 cubic yards, raising it on an average 32½ feet; this was done entirely by the pressure of the air.

At another time, the water had been forced out of the cylinder, and a few feet of sand excavated, so that the men were about 20 feet below the surface of the river, when the force-pipe burst. I was fearful for the effect it might have upon the men, both from the effects of the sudden removal of the pressure, and also the in-rushing of the water consequent upon it. I almost instantly procured a piece of rubber-packing, and, applying it over the rent, bound it fast with a cord, and was thus enabled, by running the pumps very rapidly, to hold a sufficient pressure in the cylinder for keeping the water out till the men were removed.

The men informed me that, as they were at work, they suddenly heard a loud report as of a cannon, and all was dark as night. The report was occasioned by the sudden removal of the pressure from the outside of the ear, while within, the air was condensed; the darkness was occasioned by a rapid condensation of the vapor, held in invisible suspension in the condensed air, forming a dense fog.

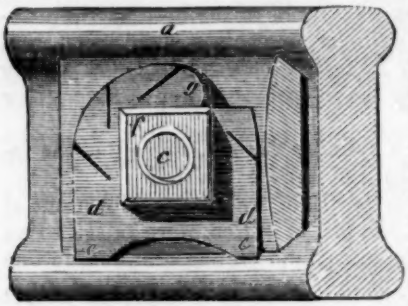
Tizard's Railway Bolt Fastener.

From the Lond. Mechanics' Mag., June, 1861.

A very important improvement has just been patented for preventing the bolts working loose in the permanent way of railways, the invention of Mr. W. L. Tizard, of Mark Lane, London, and which is intended more especially to refer to the nuts used to secure the "fishes" of the joints of rails. The nuts as now used require constant attention to fasten them up, owing to their becoming loose, consequent upon the action of passing trains.

This invention consists in the employment of a washer, one side of which is extended and has the edges turned down over the "fish-plate." A slit or series of slits are made in the washer, parallel with one of the sides of the nut, the piece between any two of the slits forming a tongue. After the nut is screwed up, one of the tongues is turned forwards, and thus the nut is prevented from turning.

The accompanying engraving is a face view, with the rail and fish-plate broken off. *a* is the rail; *b* the fish-plate; *c* is a bolt passing through the fish-plates and rail; *d* is the washer, placed over the threaded portion of the bolt *c*; it is by preference made of the best iron rolled into strips and cut the required size and shape; it has slits cut in it, as shown, whereby series of tongues are formed, and it is curved to suit the exterior surface of the fish-plate, the lower portions, *e e*, resting on the rail, whereby the washer is prevented from turning when the nut is acted on by the spanner; *f* is the nut screwing over the bolt *c*, and abutting against the washer *d*. To prevent the nut from becoming loose, turn up one of the tongues formed by the slits, as shown at *g*, against one of the flat sides of the nut, whereby the bolt is prevented from working loose. Instead of a tongue, the patentee sometimes turns up a piece of the washer, and drives a key or wedge between it and the flat side of the nut.



MECHANICS, PHYSICS, AND CHEMISTRY.

Filtration and Filtering Media.

[Proceedings of Society of Arts, May 1, 1861.]

From the London Chemical News, No. 78.

Mr. Julius Dahlke read a short, but on the whole, effective paper, at this meeting of the Society, on "Filtration and Filtering Media," of which we propose to sketch the more important points.

As we all know, filters, in some form or other, have been employed from a very early period, but the historical part of Mr. Dahlke's paper is very imperfect, and does not present a good view of the progress of the art of filtration, as it should have done, to carry out its title properly. Thus, while a casual mention was made by the Lecturer of the porous stone and earthenware filters of the ancient Egyptians and Chinese, the early Roman arrangements for this purpose were not even named, nor were the more recent processes of Peacock, Paul, Rommerhausen, Thom, Leloge, Sterling, Beart, Murray, &c., referred to in any way. As regards the scientific aspects of filtration also, Mr. Dahlke is equally deficient, but as other parts of his paper are not without merit, we proceed to quote the same.

"During the past seventy years, gravel, sand, and charcoal, used as a mixture, have been the agents most in vogue amongst filter makers, and it is only lately that due attention has been paid to charcoal as the most efficient filtering medium. Its use is much more frequent now, because not only has it a powerful detergent effect, but it

possesses also the peculiar advantage of not becoming foul, while it protects from decomposition other bodies in contact with it.

"It has been often asked why animal charcoal is so effective as a filtering medium? Some attribute this to the presence of so much carbon; but that this is an insufficient reason, is shown by the fact that, although coke contains more carbon than sand, yet it is not superior as a filtering agent.

"Animal charcoal filters about three-and-a-half times more rapidly than either coke or sand, while it is also greatly superior in this, that it removes many inorganic impurities held in solution, over which the former substances exert no power.

"It appears that the more porosity a filtering medium possesses in itself, the more rapidly does it filter, and the greater is the effect it produces on the water. The latter will be still more decided when, with a greater porosity, peculiar substances are combined.

"This leads me to believe that we may attribute the extraordinary filtering quality of animal charcoal to the fact that its principal component parts are lime and carbon, so combined as to secure a wonderfully fine porosity. Vegetable charcoal, although very porous, and containing far more carbon, has less effect on water.

"I have observed that another substance, of which I shall presently speak, and which (although of an entirely different origin) possesses great similarity in this respect, may in many cases be successfully substituted for animal charcoal. Indeed, there are doubtless numerous substances and compounds which may be used with as great effect. Do we not see that Nature supplies the most beautiful waters from limestone beds? It is hardly necessary to say, could we but imitate her action, that we should be able to do more in this as well as in other things, but we must content ourselves with as much success as our defective knowledge of her laws will permit us.

"Although we know of powerful agents for the removal of different impurities from water, circumstances may and do interpose which render it extremely difficult to obtain the medium in the requisite form for our purpose, and there is nothing yet discovered which will perfectly meet all the requirements of the case. Those who assert that it is possible to construct an apparatus to act as a universal filter for purifying any kind of water effectively, whatever may be the impurities, remind me of the vendors of certain patent medicines, who vaunt their nostrums as capable of curing every disease. Their claims are about equally trustworthy.

"I should classify the art of filtration into three systems, viz: 1st, where the action takes place simply on the surface of the filtering medium; 2d, where the whole bulk of the filtering medium is calculated to operate on the water, and the detergent effect in its most delicate form may be produced; and 3d, where both of these systems are conjointly employed.

"The first system requires a filtering medium of such a fine porosity that its pores must be smaller than the minute particles composing the impurities suspended in the water. Such an agent of course must

sooner become clogged, than a filtering medium of coarser porosity, and which is meant to act with its whole bulk on the water. But both systems employed together may prove to be useful in several instances, as in the case of domestic filters. The greatest failing of these is, that they must become clogged, and the more they are liable to this, the more effectively they act. We often hear of self-cleansing domestic filters, but the fact is that no invention of the kind has been made yet, without involving complications too great for the purposes of ordinary domestic use.

"However, it is not difficult to make a filter for general domestic purposes—although the effective self-cleansing of such an apparatus is still a problem to be solved.

"If the filtering medium employed in this case be solid, and of a fine porosity in its upper part, the clogging impurities will not only be retained on the surface, but may be easily removed by scraping; and then, if the lower part of the filtering medium be prepared of a material capable of producing a detergent effect, it will act the more readily through not being interfered with by the rougher and clogging impurities.

"It should be remembered, too, that in most cases we have here only to deal with some rougher impurities which have found their way into the water on its passage from water works, or other source, to the tap of the consumer.

"Being deeply interested in the subject of filtration, I have never omitted an opportunity of carefully inspecting those house-cisterns which came under my observation; I have, however, seen but few to which the attention necessary to secure the due cleansing had been paid. Most of them were loaded with mud, and in some of them I actually noticed the growth of vegetation (fungi*). I conclude, from my observations, that hardly one-fourth of the house-cisterns in London are in such a condition as to afford the consumer a supply of wholesome water like that which flows from the main.

"The difficulty, or I may say the impossibility, of keeping water which is stored in cisterns entirely free from accidental contamination, should lead us to provide a domestic filter capable of removing chemical impurities, as, for example, any lead which may be held in solution; in fact, the practice of filtering water preserved in cisterns and intended for domestic use, cannot be too warmly recommended.

"To remove lead from water, Professor Faraday recommends the practice of stirring up animal charcoal with the water so contaminated, the same being then allowed to settle. I have found, however, that, by using this material in a manner to be described hereafter, I never failed in producing the same effect by means of filtration.

"It is easy enough to purify small quantities of water, but the greater the quantity the greater are the difficulties of purification, especially when a certain chemical effect has to be produced.

"It will not be necessary for me to dwell upon the filtering processes required for large water-works, as the supply is generally taken

* Query—*Algæ* or *Confervæ*?

from such sources that the common sand filter-bed answers the purpose; and where the water is too hard for domestic uses, the beautiful process of Dr. Clark will meet and remedy the evil.

"Experience shows that it is not prudent to adopt the same means of purification for every kind of water, and I should make a difference in the treatment of the water used for domestic and that employed for manufacturing purposes. In the latter it will be often of the greatest importance to have the water as pure as possible, whereas certain so-called impurities in water may not be at all injurious to health. When we consider that no one would call human blood impure which contained 420 grains of saline matter per gallon, I do not know that we are justified (of course, speaking in relation to health) in calling water impure which contains small quantities of certain saline matters, particularly when we have no medical evidence that the small portions of them drunk in such water ever did any harm. Besides which, it should be remarked that the quantity of lime and magnesian salts drunk in water must be greatly exceeded in amount by that which enters the system in the food."

Mr. Dahlke had better have omitted this last paragraph, his knowledge of our language not being sufficient to show him the true signification of the words "pure" and "impure." There are a good many substances essential to the legitimate composition of our bodies that cannot be considered other than "impurities," if present in the water we drink; there is, moreover, abundance of medical and social evidence that large quantities of lime and saline matters in drinking water are productive of decidedly injurious effects, especially upon the skin, kidneys, and digestive organs.

Mr. Dahlke next said that "too pure water is distasteful, and unfit for drinking purposes," citing an illustrative case of some flat-tasting, remarkably pure water, which he had rendered more palatable by adding to it "some finely-dissolved organic impurities," and then filtering through animal charcoal.

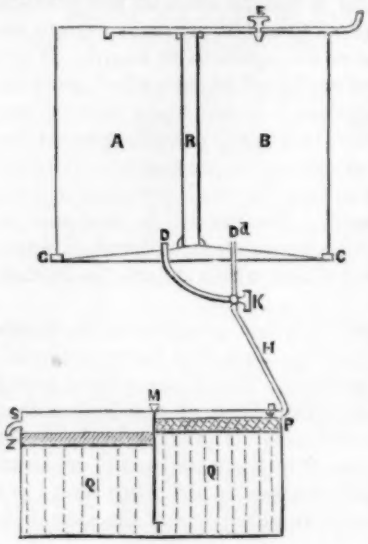
Our author prefers animal charcoal to all other filtering media, and regrets that no practical method is yet known of moulding it into blocks without diminishing its powers. Charcoal, he said, as regards its filtering qualities, stands to coke as 15 to 4, and all attempts at solidifying it by calcination with pitch, tar, &c., have failed in practice, owing to the glazing effects of the bitumen, which greatly impairs its action.

Mr. Dahlke's filter we shall shortly describe, as it appears to possess certain advantages over others of the same class that render it well worthy of notice; after various trials he found that the residue, after distillation, of the well known Torbane-hill mineral, with a small addition of fine clay, will, if saturated with fatty or oily matter,* and calcined, furnish a very powerful filtering medium, capable of reducing the hardness of water, and removing its color and odor. He also adds bone-dust, both to improve the quality of the "filter-blocks," and in order to regulate their degree of porosity with greater precision. We

* We would suggest blood, or milk, as more likely to answer the purpose.—Ed.

must now, however, permit Mr. Dahlke to describe his own filter more particularly:—

"Supposing 5000 gallons of water are daily required to be purified, that the water supplied contains nine grains of organic matter per gallon, has a bad smell, and is of seventeen degrees of hardness, I should employ an apparatus of which a wood-cut is here given:



"The upper part is a tank made from slate, completely closed, and is divided into two compartments by means of a solid filter block with one inlet, and one outlet for each of them. The supply-pipe is provided with a three-way cock, E, which allows the necessary arrangement to be made for admitting the water to one compartment of the tank, and for causing it to pass into the other through the filter-block. If, for instance, it enters at A, it has to pass through R into B, flow off by D^d, and through K and H into the second apparatus.

"This tank, being only intended to free the water from the rougher and clogging impurities, its action is to be reversed as often as may appear necessary in order to remove the collected sediment. This is easily done by shutting off the supply-pipe for A, and opening that for B; but before the water is allowed to enter the connecting pipe of the second apparatus, the accumulated impurities must be removed through the opening of the corresponding plug, G, and, that it may flow off easily, the bottoms of the two compartments are inclined towards the plugs.

"The two walls of the tank which face the filtering medium, are os fixed, that they can be opened from time to time, in order that the surface of the filter may be scoured, it being of such a consistency that its surface can be easily abraded by rubbing with hard stone.

"The water is thus freed from its coarser organic impurities, so far that they cannot possibly clog the second apparatus, which is thus retained almost entirely for chemical action on the water. It consists of a vessel which is also completely closed, with one inlet (W), and one outlet (S), divided from M to T, and fitted in the following manner:—P is a solid filter-block, cemented into the apparatus and covering the whole surface of the body, Q, thus forming the top part of this filter; it is of much finer porosity than the filtering-block in the tank, in order to separate the finer particles of organic matter from the water. The space, Q, is filled up with coarse granular charcoal and a preparation of the Torbane-hill mineral spoken of, intended to operate upon the water, so as to remove those matters held in solution which impart

color, smell, and hardness. z is a solid filter-plate, of a more neutral character, also cemented into the vessel to hold, together with P, the packing of the apparatus.

"The reason why the two materials which fill Q are employed in a rather coarse grain, is, because the oxidation of several of the impurities taking place during the filtering process, will produce considerable quantities of gases, which would soon accumulate in a finer medium and interfere with the rate of filtration, wherefore I rather prefer employing the mixture in a thicker layer.

"The dimensions of the apparatus, and the different filtering media employed in this case, will be 3 feet square by 4 inches in thickness for the filter-block in the tank; each compartment of apparatus No. 2 to be 18 inches high by 2 feet square (internal measure); its fittings are, the plate, P, 3 inches thick, Q 2 feet, and z 3 inches.

"The first clogging in apparatus No. 2 will take place on the surface of P, which can be easily avoided by removing the corresponding cover of the vessel, and rubbing the surface of P with a piece of hard stone, to which it will slowly yield, and thus be easily freed from its clogging matters, which cannot penetrate into it, the porosity of the filter-cake being too fine.

"The filter-block in the tank is so fixed that it can be taken out and replaced without much inconvenience, should it become worn out.

"The apparatus thus arranged is calculated for not less than 12 feet pressure, and its effect on such water as we supposed to have for illustration will be as follows: Organic impurities reduced to about half a grain per gallon, no trace of smell or color remains, and its hardness is reduced to about 7° or 8°.

"With regard to the continuance of the chemical effect, I admit that this must have its limits; however, from the fact that the rougher clogging impurities are so easily removed from the apparatus, and that the quantity of the inorganic impurities which will be absorbed must necessarily be comparatively small, a good portion of them escaping in the form of gas, I do not hesitate to assert that it can be successfully employed, for a considerable time, before the filtering agents get exhausted, and repacking is required.

"I do not believe it would be possible to work such a quantity of water so effectively and lastingly in such a small apparatus, if the whole of the filtering medium were to be used in a loose state, as its porosity in the latter case could not be condensed to the state of fineness required.

"This apparatus being only meant to serve for the special purpose I spoke of, it is obvious that it will have to be altered according to circumstances, both as regards the filtering agents to be employed, and its mechanical arrangements.

"If the quantity of water to be filtered be so great that a very large filter-bed is required, I prefer employing the preparation of the Torbane-hill mineral, as described, in a granular state, rather than sand; for this reason, that it filters more than three times as quick, and is five times as light as the latter; consequently a ton of it will, by a

layer of equal thickness, filter about sixteen times the quantity of water that a ton of sand would filter, with the advantage that the filtering would produce at the same time a greater decolorizing effect and a considerable softening of the water. A clogging from the precipitation of chalk is not likely to take place, as this substance is separated in a crystalline and granular state. Moreover, those particles of the material which become saturated with organic impurities may, through calcination, regain the greater part of their former efficiency."

Omitting the concluding paragraph of the Paper, which is unimportant, we have now to present to our readers the "cream" of the discussion which followed.

Mr. Spencer rose first, to deliver a speech, of which the chief object seemed to be, to lay claim to Mr. Dahlke's invention or application entirely. He had broken open one of the filters in question, and found the filtering medium contained about ten per cent. of the magnetic oxide of iron, to which, he said, all its virtues were due. He had determined (quantitatively?) the presence of this substance by means of the magnet, and accused the author of the paper of infringing his (Mr. Spencer's) patent.

Mr. Atkins set forth the merits of "carbon" *per se*, as a filtering agent, of which he had manufactured some 40,000 or 50,000 blocks, and proceeded to praise the Moulded Carbon Company and their manufactures in high terms.

Dr. Waller Lewis bore testimony to the efficacy of the filter supplied by Mr. Dahlke to a very large public department, as to its powers of deodorizing and decolorizing water. It was new to him to hear that too pure water was distasteful; and he was afraid Mr. Dahlke was assuming an untenable position. He thought inhabitants of towns were no judges of water, as their palates were disorganized by the impure water supplied to them. He had tasted the water of Lake Bala in North Wales, containing only 1½ grains of mineral matter per gallon. Many persons did not like it at first, if they had been accustomed to London water.

Mr. Painter dwelt upon the good qualities of a mixture of silica and carbon, and of the balls of the Moulded Carbon Company. These balls were cleaned by blowing air through them—a superior plan to that of Mr. Dahlke, he thought.

Mr. Danchell preferred animal charcoal to any thing else, and had abandoned all other filtering media.

Mr. Wentworth Scott said he had been called upon to make various experiments upon the relative merits of animal charcoal and prepared carbons of several kinds, as regards their power of absorbing organic matter, which resulted in favor of the first-named substance. The Moulded Carbon Company's balls were subject to the defect of having in many cases their central cavity greatly on one side, thereby modifying their action injuriously. He recommended the *platinizing* of the balls—a simple process—for waters containing much organic matter.

Mr. Morgan remarked that the public were the best judges of filters in the end. He regretted that scientific discussions were so frequently

sullied by personalities, and commented severely, but justly, upon Mr. Spencer's speech.

After a brief reply from Mr. Dahlke, a vote of thanks was passed to him, on the motion of the Chairman, for his paper, and the meeting then adjourned.

For the Journal of the Franklin Institute.

On the Erie Experiments on Steam Expansion by U. S. Naval Engineers. By Samuel McElroy, C. E.

During a part of the months of November, December, and January, of last winter, experiments were made at Erie, on the U. S. Steamer *Michigan*, under order of the Secretary of the Navy, by a Board of Chief Engineers of the Naval Engineer Corps, to determine certain questions in reference to the economy of steam expansion. Previous experiments made by the chief officer of the Board, had induced him to assert the fallacy of the commonly received doctrine of economy in expansion, and these observations were undertaken to pursue the investigation on a more perfect engine, and with greater care. A report of the results has been published by the Navy Department, of which a synopsis at length is given in the April number of this Journal, by a member of the Board.

The conclusions reported by this Board are of a very radical and revolutionary character, so far as they affect principles which have been accepted in practice from a very early period in the history of the steam engine applied to actual work. They differ from the whole tenor of experimental observation and theoretical deductions, and if accepted by the profession, would modify at once our proportions of working parts, and our applications of power. Their argument as to the economy of expansion is contained in the following quotation from the report:—

"The results obtained from this engine are rigorously applicable to all others in which saturated steam is employed in a cylinder not steam jacketed, and show conclusively the utter futility of attempting to realize an economical gain in fuel under such conditions by expanding the steam beyond the very moderate limit of one-and-a-half times; and that, if the expansion be carried to three times, a positive loss is incurred. Also, that if measures of expansion as high as those due to cutting off the steam at $\frac{1}{3}$th or $\frac{4}{45}$ths of the stroke are employed, the economy is considerably less than with steam used absolutely without expansion." It is also stated, in those cases where a reduction is to be made in power, on a cylinder cutting off at the "economical limit of $\frac{7}{10}$ths," that, as to a choice between a closer cut-off and the use of the throttle, "in fact, the two modes of reducing the power may be considered equal in rapport of economy of fuel; but, in every other respect, the choice is immeasureably in favor of the throttle valve."

Language of this kind admits of no misconstruction. It throws the gauntlet at the foot of universal professional opinion and practice boldly and unequivocally. It declares that in all ordinary working

cylinders, not steam jacketed, there is no gain in cutting off closer than at two fifths, and that a positive loss follows a cut-off at one-quarter stroke. It is better to carry full steam, we are told, than to cut off at one-sixth. And farther than this, it is better to throttle the steam for any reduction inside of seven-tenths cut off, than to cut off with the main valve.

An opinion of this kind, expressed in this way, has a certain gravity, and merits an attention which might be denied the publication of any individual conclusion to the same effect. It claims to be issued by authority, it involves the honor of the Naval Engineer Corps, it passes out to other countries as the conclusion of American science, and it pretends to be infallible. This Board informs us that its report is "only one more illustration of the well-known fact that the histories of all sciences are but records of mistakes and misconceptions, arising from the application of fallacious theories, which, once plausibly advanced, were long believed in, from an unwillingness to investigate for ourselves, but which exploded at the first touch of the *experimentum crucis.*" It is a matter, therefore, of some interest to the profession to inquire how far this assumption of new light will in itself bear the test which is claimed to have been applied, for the first time, to all the past.

We may justly, then, in our examination of these opinions and the experiments on which they are based, subject them to severe analysis, in order to detect any sources of error. All revolutions, political or scientific, must be content to bear the burthen of proof, and cannot be allotted the benefit of any doubts. If, in ordinary processes, according with established principles, we may leave unquestioned between the initiative and the final result many of the intermediate operations, it is manifest that nothing of the kind can be claimed or allowed in a case like this, which seems to contravert well-known and long-established mechanical laws. And we have, therefore, a right to determine that this report shall only be accepted, if its experiments were correct as to the principle of experiment, the method of experiment, and the most consistent and conclusive results of experiment. Any contradictions occurring at any stage of the process, any palpable or possible errors in process, any anomalous results or inferences, are fatal to the whole, and must be so received. The first great lesson which a thorough-bred engineer learns, is to take nothing for granted; and however we may personally respect and value the character and experience of the members of this Board, we must judge of their verdict by fixed and positive conditions of analysis, and in no other way. If they have failed to determine with rigid accuracy a single important link in the chain of evidence, the report falls to the ground; and if processes in detail are suppressed, requisite to establish evidence, the argument of the report is, so far, vitiated.

The reader of this report cannot fail to be impressed with its parade of accuracy. Elaborate descriptions are given of certain precautions taken, and sizes in close detail of the boilers and engines are recorded with interesting fidelity. The precise number of inches between the

bottom of the feed-water tank and the floor is not omitted: Equally elaborate are the arguments on the results obtained, both which features comprise a report of some 38 pages. But when, with some educated regard for such matters, we examine this report for the *notes of the experiments* in similar satisfactory detail, we are surprised to find them entirely omitted, and have no key to them whatever, except the aggregated results given in two tables, arranged in seven columns, allotted to as many distinct experiments. These tables are merely averages and aggregates of the results in detail, and therefore define the several processes in a general way. To have known precisely the times and manner of coal supply, tank supply, cleaning fires, starting and hauling fires, variations of pressure, and the like, as to the boilers, we might well have excused an elaborate notice of the kind, material, and diverse sizes of their flues, or any other matters irrelevant to the questions at issue. And this remark is applicable to all the other processes tabulated. The counsel for the defendant has no opportunity to cross-question the witnesses. The argument is confined to the general allegations. We do not mean to convey the impression here that these tables are incorrectly reported, but we do intend to say, that the report has a pretension of accuracy in detail which is not warranted by its actual statistics of essential points. It does not enable us to decide any questions suggested by the tables themselves.

The correctness of the opinions expressed by the Board is to be judged by the results obtained by it, so far as the course of examination adopted was in itself correct. If any objections exist as to any portion of such course, they invalidate, in proportion to their character, the results obtained. The first point, then, to be considered, is the Course of Experiment pursued.

The following general description of method is deduced from the statements of the report:—

The ship has two engines and two boilers. The starboard engine and both wheels were used, with *both boilers*, for all the trials reported, the port engine being disconnected.

The boiler evaporation was determined by indicator cards taken hourly, and by tank measurements.

Each experiment continued precisely 72 hours; there being 7 reported with a steam travel in the cylinder varying from $\frac{1}{2}\frac{1}{2}$ths to $\frac{4}{4}\frac{4}{5}$ths.

The boiler pressure was nearly uniform in all the trials.

The ship was secured to the wharf, so that the wheels paddled the water aft.

Before an experiment, the engine was operated for several hours. When all was ready as to water level and boiler pressure, with "average fires," the notes were commenced. At the close, the boiler level was corrected, and the fires made the same "as nearly as could be estimated." The friction and resistance of the engine and wheel-arms and rims, were determined by taking off the floats, and working the engine from 6 to 22 turns, taking indicator cards to obtain a reliable mean for each rate of speed.

During an experiment, the engine was neither stopped, slowed down, nor in any way changed in condition.

Due precautions were taken as to the tightness of valves, &c., correctness of counter, coal account, and other important notes.

To illustrate more fully the course of experiment adopted, the following abstract is made from table No. 1 of the report, which gives the "data and results." Table No. 2 equates these results in various ways, and is based on No. 1.

No. of experim't.	Date of commencement.	Boiler gauge pressure.	Mean cylinder pressure.	Vacuum.	Cut-off.	Revolutions.	H. P.	Coal per sq. foot of grate.	Coal per H. P. per hour.	Feed-water per lb. coal by tank.	Kind of coal.
1	Dec. 30, 4 A.M.,	21	19·9	25·8	3-10	13·69	133·7	6·28	4·23	8·33	Ormsby.
2	Jan. 2, " "	"	13·6	25·6	1-6	11·17	74·5	3·79	4·58	8·09	"
3	" 5, 6 "	"	17·4	25·8	1-4	13·87	118·4	5·21	3·96	8·70	"
4	" 8, 10 "	"	24·1	26·3	4-9	17·28	204·4	9·51	4·19	7·90	"
5	" 18, " P.M.,	19·5	27·6	26·1	7-10	15·56	210·8	11·41	4·87	7·14	Anthracite.
6	" 21, 12 "	21	29·8	26·5	11-12	20·61	301·4	18·52	5·53	7·22	Brookfield.
7	" 25, 6 "	22	8·8	24·1	4-45	14·10	60·9	4·11	6·08	7·58	Ormsby.

Notwithstanding the claim of this report that it is the "*experimentum crucis*" which has, for the first time, successfully opposed rigid experiment against "fallacious theories," we shall assume here, that there are certain general principles by which its particular course is to be tested, which overrule any experimental results, and decide the question of acceptance or rejection by positive laws.

We shall not pause here to defend this assumption by any argument at length. It is a great mistake to assert, in these latter days, that engineering is a science hitherto purely theoretical. On the contrary, it is clear that its laws have been gradually determined from the absolute results of long continued observations, and eliminated from the unmistakable precepts of actual trial. This is the glory of the profession, that from known results it has framed its precepts and laws, under the guidance of which, in certain established methods, it may claim infallibility, without arrogance. And it is the leading principle of the profession, that all conjecture and discussion should be brought to the test of trial and by such test to stand or fall. There is no need of multiplying words or adducing evidences of so well known a statement as this. Every engineer who has had to assume the responsibility of important constructions, knows by experience that it is true.

As appears from its report, the Board, in experimenting, adopted a uniform standard of low boiler-pressure for all the variations of work, and changed the resistances of the wheels by removing the floats. For all grades of expansion then, low steam was used, a uniform initial pressure, and variable resistances.

We object to the correctness of this method, for the following reasons :—

The problem which presents itself to an engineer in operating his engine and his boilers, is defined by the amount of work to be done

and the most economical method of doing it within limits of safety. And with a given engine in place, like the *Michigan's*, the argument between expansion and non-expansion should have been determined by a fixed standard of piston resistance, and not by a fixed standard of boiler pressure, with variable resistances. Viewed in this light, which is the only correct one, the mission of this Board was to experiment, first on such a boiler pressure as with a full steam stroke would fulfil the usual duties of the engine, and then maintaining the same *average cylinder pressure*, and the same engine duty, to test the economical results with successive degrees of expansion, and corresponding increments of initial pressure. This is the real matter at issue—whether it is cheaper to carry high steam and expand, or to carry low steam and follow at full stroke.

As to its opinion on this subject, the Board, in a part of its report, leaves us distinctly to infer that its results, as tabulated, are conclusive against the use of higher steam. Its argument, as given on pages 33 and 34, is based on the assumed fact that it has demonstrated an immense loss in any high range of expansion, and it follows by consequence, that a greater boiler pressure, as involving a closer cut-off, would be useless. Unfortunately for our confidence in its tables, which will not be found to bear analysis, it has not favored us with any practical demonstration of its singular logic, and as it seems to be simply Quixotic to pause here, for the purpose of establishing the proposition which is plain to the rudest coal-heaver, that it is cheaper to make high steam than low steam, we content ourselves at present with saying that this neglect, in itself, as a misapprehension of principle, is sufficient to overthrow all these carefully eliminated tables and high toned results. The relative economy of high and low pressure for a given amount of work has long since passed beyond the region of conjecture. Those of us who have seen engines of enormous contract value, hanging for acceptance or rejection on the rise of the boiler gauge, and the curve of an indicator card, know something of this in practice, and by demonstrations of the highest order.

Again, we find in these experiments, that with the same pressure and the same grate surface, the rate of combustion in the boilers varies from 18·52 pounds per square foot to 3·79.

In this way the Board disposes in a very summary manner of the discussion which has long agitated the engineering world, as to the relative merits of quick and slow combustion. While one class has claimed superior advantage in slow combustion, and has specially adapted its boilers to this process, their opponents pronounce in favor of quick combustion, and modify their forms accordingly. The discussion also embraces varieties of coal, one being deemed most suitable for a slow fire, and another for a stronger fire. Volume after volume, experiment after experiment, debate after debate, are extant on this subject. But here, without argument or apology, this "fallacious" range of opinion is laid upon the shelf, and in the same boilers, with the same variety of coal, the rate of combustion is varied about *four hundred* per cent.! And the highest rate is that required, of all these,

for the ordinary speed of the ship, for which these boilers were proportioned. The tabular results of this board, then, are just as valuable and just as conclusive on the theory of variable combustion as they are on that of variable expansion.

It has been claimed, and demonstrated by experiment in important cases, that the proportions and conditions of a boiler being constant, there can be but one rate of combustion in correspondence with its *maximum useful effect*. This is a recognised law of practice, and is true of either a quick or slow combustion boiler. Farther than this, it has been claimed, that the *useful effect* of a boiler is modified by the manner in which its steam supply is taken, whether more or less rapidly, and in approximation to a certain rate of supply. But the course of experiments under examination exercises a supreme contempt for these distinctions. Not only is the rate of combustion varied, as we have stated, but the rate of steam supply, in equal times, varies *six hundred* per cent.! The performance of these boilers, judged by the results tabulated, does not reach, by at least 25 per cent. of evaporation, the standard of reasonable expectation, and in no two experiments is the evaporation alike per pound of coal. When we are told that special care was exercised in all the experiments to keep the throttle open, although the Board claims to have demonstrated certain singular conclusions about throttling, we can readily understand with what ingenuity these boilers were themselves throttled out of their vitality.

The doctrine of *maximum useful effect*, which defines the load and the velocity of an engine is also placed at issue here. Theory has been confirmed, in repeated instances, as to this law, which has engaged the attention of our most profound students. A certain standard of proportion exists between the leading features of an engine and the amount of labor it will best perform, and no violence can be done any of its conditions of service without detrimental results.

The steamer *Michigan*, as a case in point, was built for Lake service, with a certain proportion of machinery to her displacement and speed. From notes of her performance, we find that with a mean piston pressure of 18·44 pounds per square inch, she makes 18½ revolutions per minute, and 10·4 statute miles per hour. As a side-wheel steamer, with two engines and two boilers, these are her ordinary conditions of work. But, in experimenting with her, all these relative proportions are violated. One engine is disconnected, and both boilers are kept under fire to supply the other, although with the same initial pressure the revolutions are varied from 20·6 to 11·17, and the mean pressure (a representative of the load) is changed from 29·8 to 8·8 pounds per square inch. And yet the Board seems to be under the impression that all these changes are compatible with a common standard of useful effect, and practically denies a most important principle of mechanical action. In this respect we are not prepared to concede its infallibility.

In connexion with this objection a question of fact arises, as to the literal accuracy of the report. The Board attempted to carry out a

mistaken principle of trial by regulating the resistances of the wheels, so as to accommodate a uniform initial pressure, and it succeeded very completely in producing a variously diseased and incongruous action of the engine; but it is incorrect in asserting that it "was not in any way changed in condition" of motion during any experiment, inasmuch as the waves were affected by the wind, and the dip of the floats varied as the vessel alternately grounded or floated, and the floats themselves were, from time to time, broken by ice. These resistances, by consequence, could not have been uniform during any experiment.

A glance at the tabular synopsis sufficiently indicates the effects of these variable resistances. The results in action are much more diversified than the changes in rate of expansion, and are strikingly inconsistent. A mean pressure of 8·8 pounds produces 14·1 revolutions, while that of 13·6 pounds gives only 11·17 turns. We increase the pressure 60 per cent., and it reduces the speed 21 per cent. A range of 603 per cent. has been noticed in the quantity of steam used in a given time; there is a range of 240 per cent. in the mean pressures; a variation of 10 per cent. in the vacuum; of 84 per cent. in speed; of 390 per cent. in combustion; of 50 per cent. in coal per H. P.; of 22 per cent. in evaporation.

And the argument of the report is embarrassing in these conflicting cases. There stand the tables of the new law. Whatever opposes their "data" is "fallacious," and it is just as incontrovertibly true, that an increase of pressure will reduce speed in all engines not steam-jacketed, as it is that it is cheaper to follow full stroke than to cut off at one-sixth.

On page 13, the report states that "during all the experiments the throttle valve was kept wide open." On pp. 36 and 37, we have the argument, already quoted, that for anything below a steam travel of seven-tenths, it is "immeasurably" better to throttle than to use the main valve.

Here the Board, not having experimented, passes into the dangerous region of "fallacious theories," and jeopardizes its infallibility. Engineers are under the impression that the moment of final pressure determines the amount of steam expended during an engine stroke. And it is a simple mechanical impossibility that the same *mean pressure* in connexion with a given *final pressure* can be produced, where the throttle is used instead of the main valve cut-off. All experience goes to confirm the very plain principle that throttling reduces the initial range of pressure, and consequently the mean pressure, which determines the amount of work done, while the final pressure, which measures the cost of the work, remains constant in either method; and there is therefore a loss of power equivalent, at least, to such reduction of pressure. An assertion of opinion, like that quoted, coming from such a source, cannot but be regarded with surprise. Not only is it incorrect as to economy of fuel, but in all well arranged engines, it is as easy to modify the cut-off gear as to change the throttle. There may be an exception in the case of those horribly proportioned guillotines with which the Navy steamers have been afflicted of late years;

which have 6 inches clearance and 54 inches diameter for 32 inches stroke; which spin around sixty-five times a minute to achieve eight knots an hour; and of which an "assistant" stands in mortal fear, from the time they are "hooked on" until they happily break down, and are laid up for repairs.

It was to be presumed that the Board would trace their special theory through a regular series of demonstrations to a final conclusion in their method of experiment. But our table shows that no order of this kind was observed in the variations of expansion, as its report also shows that it argues on certain grades, which it did not test. Experiment No. 7 in date, as the greatest in grade, immediately succeeds that of the greatest steam travel, and the relative order of the series, in this respect, is Nos. 6, 5, 4, 1, 3, 2, 7, as distinguished from their dates. If the results obtained developed a regular series, we might be content to accept them, no matter in what order of precedence, but these are as irregular as their order of trial. The consumption of coal per H. P. per hour is thus reported: 3·96 lbs. for $\frac{1}{4}$ cut-off, 4·19 lbs. for $\frac{1}{8}$ths, 4·23 lbs. for $\frac{3}{10}$ths, 4·58 lbs. for $\frac{1}{6}$th, 4·87 lbs. for $\frac{7}{10}$ths, 5·53 lbs. for $\frac{1}{1\frac{1}{2}}$ths, and 6·08lbs. for $\frac{4}{4\frac{1}{2}}$ths. Such a result as this, taken in connexion with the fact that the last trial shows about three times the combustion per H. P. due to some engines, is a painful commentary on the method of experiment adopted.

We may also observe here, that a number of experiments were made at Erie, which are not given in the report. The Board convened Nov. 19th, and the first result tabulated bears date Dec. 30th, although notes of experiments on the 1st, 5th, 8th, and 10th are extant. Of these the Board remarks, that "it is useless to add any others (to those given) which *uncontrollable variations* in the conditions during their progress could lay open to a doubt," although they are said to have shown less effect from the measures of expansion. The inference to be drawn from this omission, on these grounds, is by no means an argument in endorsement of the report, nor does it sustain the general *modus operandi*. Details of experiments are not only suppressed, but whole experiments themselves, probably equal in number to those given, are also suppressed. The witnesses do not tell the "whole truth."

Nor does the text of the report accord with the "data" tabulated, in an important matter of fact like the following:—

On page 12, we are told that "Each experiment lasted 72 consecutive hours, during which the engine was neither stopped, nor slowed down, nor in any way *changed in condition*. In commencing an experiment the engine was operated for *several hours* to adjust it *to the normal conditions* required to be *uniformly* maintained during that experiment, and to bring the fires to steady action." But when we turn to the tables which form the basis of the text, we find that while Experiment No. 1 terminated its 72 hours run at 4 A. M., Jan. 2d, Experiment No. 2 commenced at precisely the same moment. We also find that there was but two hours interval between Experiments Nos. 2 and 3, and 5 and 6. In a simple matter of fact, then, three experi-

ments out of the seven are open to discussion, as to the statements of the text.

But this is not the most serious point of this objection. It will be noticed that the combustion of coal per square foot of grate is 6·28 lbs. for No. 1, and 3·79 lbs. for No. 2; that the evaporation varies from 8·33 lbs. per lb. of coal to 8·09; that the mean cylinder pressure (which reveals a varied resistance) changes from 19·9 lbs. to 13·6, and the cut-off from $\frac{3}{16}$ths to $\frac{1}{8}$th, or as 18 to 10, and the revolutions from 13·69 to 11·77. Now we would like to be informed by what medium, unrevealed to ordinary philosophers, this Board was enabled to change the combustion of the boilers 51 per cent. in rate, at the tick of the second-hand which changed Experiment No. 1 to No. 2, and by what process they defined all the other changes of resistance and methods of action, which clearly distinguish these experiments. Their special claim of accuracy cannot meet the argument of this self-evident tabular conviction.

The Board suppresses a number of experiments on account of "uncontrollable variations." In those which they present we find that—

There is a variation in the boiler pressure from 19·5 to 22 lbs. per square inch.

There is a variation in the vacuum from 24·1 to 26·5 inches.

There is a variation in the evaporation per lb. of coal from 7·14 to 8·70 lbs. of water.

There is a variation in the coal used, three kinds being reported.

In matters of simple management like these, the discrepancies are inexcusable, and tend to complicate the results needlessly. Especially is it strange that different kinds of coal should be admitted under any circumstances, the variety used for the greatest steam travel differing from that in any other experiment.

(To be Continued.)

On the Nature of the Deep-Sea Bed, and the Presence of Animal Life at Vast Depths in the Ocean. By Dr. G. C. Wallich.

From the Lond. Engineer, No. 279.

Our first clear glance at the floor of the ocean may be said to date from the period at which submarine telegraphy was first undertaken. For although the depth of the sea has been approximately ascertained over widely extended areas, in the course of the various surveys conducted under the auspices of the British, the United States, and the Dutch governments, hardly any previous attempts have been made systematically to investigate the characters and composition of its bed. In the absence of any special object, such attempts would have been far too costly and difficult to be practicable. It has been ascertained, however, that the floor of the ocean is but the reflex, as it were, of the dry land; that it is in no place unfathomable; that along its deeper portions certain muddy deposits are to be met with, in many cases made up, more or less entirely, of minute calcareous shells belonging

to one of the most simple order of beings with which we are acquainted; and that together with these are also to be found, but in, comparatively speaking, small quantity, the minute flinty skeletons of other organisms derived both from the animal and vegetable kingdoms. But no conclusive evidence has been produced to show whether any or all of these organisms normally lived and perished, at the profound depths from whence they were obtained by the sounding lead; or whether, having inhabited distant and, perhaps, shallower seas, their dead remains alone, after being transported by currents, or other agencies, had gradually subsided into the deep hollows of the ocean. Taking into consideration the very important part played by these organisms in the structure of the earth's crust, that vast strata have, in ages gone by, been built up of them, and that similar strata are at the present time being deposited along the beds of existing seas, the investigation of these questions becomes of the highest consequence, as bearing on the successful establishment of ocean telegraphy.

The distribution of animal life in the upper waters of the sea, is determined by climate, by the composition of its waters, the nature of its bed, and its depth in any given locality; the last of these items necessarily involving the relative degrees of temperature, light, æration, and pressure, as compared with those to be met with near the surface. Of these conditions, climate exercises a very powerful influence; for it is found as we advance from the equator towards the poles, that a gradual diminution takes place, not only in the number of types met with, but of the varieties ranged under those types. It has been maintained that, in order to compensate for the diminution in the number of generic forms, the number of individuals of each species is much augmented. Although this law holds good as regards the higher orders, it can hardly be said to do so in the case of the lower; for the vast assemblages of these lower forms met with on the surface of the sea in the tropics, are in no wise less extensive than those met with in high latitudes. It will be found that, the lower the grade of being, the more equally balanced will be its distribution at the extremes of the globe; inasmuch as the greater range in depth commanded by these lower forms renders them less amenable to conditions which are variable from being dependent on atmospheric changes.

The composition of the waters of the ocean is well known to become much more equable at great depths; and it, therefore, exercises a far less marked influence on the presence of animal life than it does at the surface. The same causes which equalize the temperature in so remarkable a manner as the depth increases, are effective in equalizing the relative proportions of the various ingredients that enter into the composition of sea water, in all latitudes. For whilst the surface stratum is subject to dilution with fresh water, from various sources, the greater the depths the less subject can the waters be to this influence, and the less can it operate in modifying the distribution of the organisms that frequent them.

Oxygen is essential to the presence of animal life—without it ani-

mal life ceases. To air-breathing as well as water-breathing creatures, a due supply of this gas is indispensable; the function of respiration, no matter whether performed by lungs, as in man and the higher orders, or by a simple process of absorption and exudation through the general surface of the body, as in some of the lower forms, being in every instance essentially that process whereby oxygen is received into the system in exchange for carbonic acid, which is given off. But although oxygen enters largely into the composition of both atmospheric air and water, the supply of this element is not obtained, in the case of creatures inhabiting the sea, under ordinary circumstances, from its decomposition, but from a certain portion of atmospheric air present in water in a state of solution. Most gases are absorbed by water. Under pressure, the quantity absorbed is much increased, as is seen in the familiar case of soda-water. It should be borne in mind, however, when the fact is applied to the occurrence of animal life at great depths in the sea, that, in order to produce the absorption of atmospheric air, its contact or mixing together at the surface by the action of wind and wave is necessary, and the effect of this operation can only extend to a limited depth, unless, as has been assumed by some of our highest authorities, the lower strata of sea water, being subject to increased pressure, becomes capable of holding in solution a greater quantity of oxygen; and, by robbing the superincumbent strata of that which they contain, gradually become saturated with it. Should this view be correct, there must be a point at which the maximum amount of oxygen which sea water can absorb is permanently present in it. But, inasmuch as the vegetable cell, simple though it be in structure, can eliminate carbon from the medium in which it lives, it is not unreasonable to assume that the lowest forms of animal life, even where no specialized organs are traceable, may, in like manner, be able to eliminate oxygen directly from the water around them.

The temperature of the sea is materially influenced by the climatic conditions of different latitudes; and, of course, exercises a powerful effect both on the distribution and abundance of the higher orders of living beings present in its waters. But, as has been shown, this influence is not manifest, or, at all events, not so manifest in the lower orders; for, at great depths, the variability of the temperature is reduced within very narrow limits in all latitudes. Now, the higher orders of oceanic creatures inhabit only the surface waters, never sinking down to extreme depths. In the case of some of the lower forms, on the other hand, a very extended pathymetrical range exists, putting out of the question those which constantly dwell on the sea bed itself, of which I shall presently have to speak.

In like manner, light, or rather the absence of it, can hardly be said to determine, in any important degree, the distribution and limitation of the lower forms of animal life. Light is not essential, even in the case of some of the higher orders. A large class of creatures, both terrestrial and marine, possess no true organs of vision, although there is good reason for believing that they do possess some special

sensory apparatus, susceptible to the influence of light; whilst certain creatures, whose habitation is in subterranean caves or lakes, as in the Magdalena caves near Adelsburg and the Great Mammoth caves in Kentucky, either possess no organs of vision, or possess them in so rudimentary a state as to prove clearly that the absence or imperfect development of this sense may be compensated for by the higher development of other senses.

It is impossible at present to say to what depth light penetrates in the sea. The photographic art will, no doubt, one day solve the problem. But it is almost certain that a limit is attained, and that moreover long before the deep recesses gauged by the sounding machine are reached, where the light-giving portion of the ray cannot penetrate, even in its most attenuated condition; and yet, as shall hereafter be shown, creatures have been found down in those profound and dark abysses, whose coloring is as delicate and varied as if they had passed their existence under the bright influence of a summer sun!

Pressure is the last condition which has to be noticed. Although undoubtedly a highly important one, I hope to be able to prove that it is not of essential value, as has heretofore been laid down, in determining the final limit of animal life in the sea.

It is almost needless to state that, at the sea level, there exists a pressure of 15 lbs. on every square inch of surface, due to the weight of the atmospheric column resting upon it; and that the pressure on the successive strata of water in the sea, as the depth increases, is infinitely in excess of this, inasmuch as a column of water only 33 ft. in height, is capable of counterbalancing the entire atmospheric column, which extends to a height of about 45 miles. Accordingly, for every 33 ft. of descent in the sea, putting out of consideration the effect of the superincumbent column in actually diminishing the bulk of the portions beneath by augmenting their density, there is an additional 15 lbs. At great depths, therefore, the aggregate pressure becomes stupendous. As is well known, pieces of light wood let down to a depth of 1500 or 2000 fathoms, become so compressed and surcharged with water as to be too heavy to float. But there is a fallacy in this experiment; for the contraction of the woody fibre and cells is a necessary consequence of their submission to an amount of pressure so enormously in excess of that under which they originated. With organisms which have been developed, from first to last, under the full operation of any given amount of pressure, the result would not be of this nature; for the equalization of the pressure within and without their entire structure, although it might possibly exercise some definite effect in determining their shape, size, or even functions, cannot, I submit, operate in causing the creatures living under it to experience any more detrimental results than we experience from the 15 lbs. on every square inch, or about 14 tons on the general surface of our bodies, near the sea level.

It can scarcely be wondered at that, under such apparently extraordinary conditions, the maintenance of life, even in its least developed aspect, should have been deemed absolutely impossible at extreme

depths; and that it should have been almost unanimously recognised as an axiom, that, at a depth of 400 or, at most, 500 fathoms, life, whether animal or vegetable, must be extinct. The fact is unquestionable that, as we descend beyond the first hundred fathoms, the traces of life become more and more remote; and it is probably owing to this gradual diminution in the number of animal forms, as the depth exceeds this limit, that it has been assumed, rather as a matter of theory than of observation, that a point is speedily reached at which all the conditions essential to life are extinguished. This view has also derived support from the idea that "animal life depends on the previous existence of vegetable life." In the case of the higher orders of the animal kingdom, the law, no doubt, holds good. Not so, however, in the case of the lower. The conditions essential to the perpetuation of the one are not essential to the perpetuation of the other. Thus, light is indispensable for the healthy respiration and growth of the vegetable. The animal can, on the other hand, respire as freely in the blackest darkness as in the broad glare of day. And this is, no doubt, the reason why vegetable life in the ocean attains its final limit in depth so much sooner than animal life. And yet, considering how very unexpectedly animal life has been proved to exist deep down in the ocean—as I shall immediately show, far removed beyond those conditions which had hitherto been considered indispensable—we ought perhaps to pause before we assert that the same plastic skill which has so constituted certain creatures as to admit of their inhabiting the deep abysses of the ocean, may not, in like manner, have so constituted some of the vegetable organisms as to be capable of living under similar conditions.

(To be Continued.)

On the Employment of Lighting Gas in Acieration. By M. GRUNER.

From the Lond. Chemical News, No. 82.

In the *Comptes-Rendus* of the 11th of last March, M. Fremy put the question to metallurgists whether his experiments relating to the conversion of iron into steel by means of lighting gas could not be practically utilized. In the name of metallurgists, let me be permitted to reply, that practice has long since positively decided this point.

Twenty-five years ago, Mr. Macintosh, an ingenious Glasgow manufacturer made several tons of cemented steel by submitting iron, at a dull red heat, to the action of lighting gas, operating with from 100 to 150 lbs. at a time, the iron bars being two inches broad and six lines thick. The cementation took from eighteen to twenty hours, and when the operation exceeded that time, supercarburation took place.

M. Dufrénoy published these details in the third series of the *Annales des Mines*, vol. v., p. 171. He had himself seen specimens of this steel, a portion of which was melted and then worked by the ordinary means. M. Dufrénoy says that the supercarburated thin bars nearly resembled graphite. Thus, then, by the sole action of lighting gas, without mixture of any foreign body, it is possible to obtain

either steel or cast iron; it is only a question of time or temperature. To obtain steel, there is no need to add ammonia previously in order to nitrogenize the iron. In fact, as M. Caron judiciously remarked, at the meeting of March 18th, coal gas always contains ammonia, and it is not my intention to deny its influence on cementation. I will not further attempt to solve the question of the presence or absence of nitrogen in steel; but it appears to me certain that, if nitrogen exists in steel, it exists equally in cast iron. Moreover, it is twenty years since Dr. Schafhaütl of Munich stated positively that he had found nitrogen in cast iron.

It must be remembered that, in ordinary cementation with wood charcoal, as in Mr. Macintosh's experiment, iron is *gradually* brought to the state of steel, and then to that of cast iron. There is no precise limit between these three stages. At what period of the operation, and by what reaction, will the nitrogen previously absorbed again quit the iron? In malleable cast iron, whence comes the nitrogen if not contained in the cast iron itself? And in puddled steel, how can nitrogen combine with iron or carbon if cast iron does not contain it? I showed, in a paper on puddled steel, published a year ago in the *Annales des Mines*, vol. xv., that the fining of cast iron in a reverberatory furnace takes place under a coating of slag containing iron and manganese when puddled steel is to be obtained. I ask, then, how the hot atmospheric nitrogen of a furnace can combine with iron and carbon across this coating of scoria? Certainly, if puddled steel contains nitrogen, it can only proceed from cast iron, and it appears to me as interesting to prove its presence in cast iron as in steel itself. But let me be allowed to raise some doubts on the possibility of proving the presence of nitrogen in steel by hydrogen. At red heat, iron takes away the nitrogen from ammonia and sets the hydrogen at liberty; and at the same temperature will this hydrogen again take away the nitrogen from the iron,—from the iron which is always in excess relatively to the gaseous molecules which can react on it? It is more difficult to conceive the production of ammonia under these circumstances than the direct combination of hydrogen with free nitrogen.

Another fact which proves that steel and cast iron differ only in containing diverse proportions of the same elements is, that pure white cast irons can be tempered and even forged like steel; witness the white cast iron of Sieges, used for making screw-plates.

Finally, if forged natural steel contains nitrogen, this element ought also to be found in cast iron; and in the second place, it has long been proved that iron can be transformed at will, either into cast iron or steel, by ordinary or coal gas cementation. To effect either, a difference only of time and temperature suffices.—*Comptes-Rendus.*

Giffard's Injector.

From the Civ. Eng. and Arch. Jour., June, 1861.

The principle of Giffard's Injector appears to have been known upwards of a century ago. In 1753, Richard Savery of Birmingham, published a book in which he gave a plan and description of an apparatus for raising water by steam. A conical nozzle, discharging a

jet of steam, was shown within another similar nozzle, as in the Injector, the water being thus drawn up through and discharged from the annular passage. Among other copies of Savery's book, one is now preserved at Messrs. Elkington and Mason's of Birmingham.

Austrian Horse-Power.

From the Bulle. de la Soc. d'Encour. pour l'Indus. Nat.

The Austrian government has fixed the legal horse-power in that empire at 430 *pfunds* raised 1 *fuss* per second. This is equivalent to 76 kilogrammes raised 1 metre per second, or 32,982·85 lbs. raised 1 foot high per minute.—*Dingler's Polytech. Blatt.*

Report on Steam Boiler Explosions.

From the Lond. Mechanics' Magazine, June, 1861.

The monthly meeting of the executive committee was held on Tuesday, May 28, at the offices, 41 Corporation Street, Manchester; Hugh Mason, Esq., vice-president, in the chair. Mr. L. E. Fletcher, chief engineer, presented his monthly report, from which the following is extracted:—"During the month, we have made 195 visits, examined 501 boilers and 339 engines. The following are some of the principal defects which have been found to exist in the boilers inspected, and to which the attention of the owners has in each case been called:—Fracture, 14; corrosion, 16 (four dangerous); safety valves out of order, 21; water gauges ditto, 12; pressure gauges ditto, 8; feed apparatus ditto, 2; blow-off cocks ditto, 17 (one dangerous); fusible plugs ditto, 3; furnaces out of shape, 9 (two dangerous); over pressure, 1; deficiency of water, 1: total, 104 (seven dangerous). Boilers without glass water gauges, 65; ditto pressure gauges, 9; ditto blow-off cocks, 23; ditto feed back pressure valves, 76. After alluding to a case where a tubular boiler had been materially injured by incrustation, the report went on to state:—"I am so constantly meeting with cases of this sort, where, from the neglect of the simple precaution of blowing out, a good deal of property is sacrificed, that, even at the risk of repetition, I cannot forbear calling the attention of members to it. I am constantly asked what should be done to remove incrustation which should never have been allowed to form; and beg to recommend, as the most simple means for its prevention, regular blowing out from the surface when the water is in ebullition, and from the bottom when it is at rest. I find the blow-out apparatus in many boilers very inconvenient, if not entirely unfit for use, some of the taps being so made that they cannot be opened—or, if opened, cannot be closed; others being rammed full of horse dung till quite choked, to prevent leakage; while many have no waste pipes, so that the boilers can only be blown out when the pressure is low, for fear of scalding the men, and thus the practice is too frequently confined to the weak end. I would strongly urge upon our members the importance of depriving their engine-men of all excuse for neglect, by having the apparatus for blowing out, both from the surface of the water as well as from the bottom, put in complete working order, and

then let it be understood that further incrustation in their boilers is not to occur. This, I can assure them, would save them the trouble and expense incurred by many of constantly dosing their boilers with patent medicines. I may add, that perhaps as little trouble is experienced with a tap made with a close bottom, entirely of brass, and fitted with a gland, as with any other arrangement."—*Manchester Guardian.*

For the Journal of the Franklin Institute.

Strength of Cast Iron and Wrought Iron Pillars: A series of Tables deduced from several of Mr. Eaton Hodgkinson's Formulæ, showing the Breaking Weight and Safe Weight of Cast Iron and Wrought Iron Uniform Cylindrical Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 192.)

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $w = 42{\cdot}8\frac{D^{3{\cdot}76}}{L^2}$.	Safe weight in tons.
5	30	2	21·10		5·27
6	36	"		16·10	4·02
7	42	"		11·83	2·95
8	48	"		9·05	2·26
9	54	"		7·15	1·78
10	60	"		5·79	1·44
11	66	"		4·79	1·19
12	72	"		4·02	1·00
13	78	"		3·43	0·85
14	84	"		2·95	0·73
15	90	"		2·57	0·64
16	96	"		2·26	0·56
17	102	"		2·00	0·50
18	108	"		1·78	0·44
19	114	"		1·60	0·40
20	120	"		1·44	0·36
5	24	$2\frac{1}{2}$	42·34		10·58
6	28·8	"	33·58		8·39
7	33·6	"		27·34	6·83
8	38·4	"		20·93	5·23
9	43·2	"		16·54	4·13
10	48	"		13·39	3·34
11	52·8	"		11·07	2·76
12	57·6	"		9·30	2·32
13	62·4	"		7·92	1·98
14	67·2	"		6·83	1·70
15	72	"		5·95	1·48
16	76·8	"		5·23	1·30
17	81·6	"		4·63	1·15
18	86·4	"		4·13	1·03
19	91·2	"		3·71	0·92
20	96	"		3·34	0·83

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $W = 42{\cdot}8 \frac{D^{3{\cdot}76}}{l^2}$.	Safe weight in tons.
5	20	3	72·88		18·22
6	24	"	59·45		14·86
7	28	"	48·83		12·20
8	32	"	40·47		10·11
9	36	"		32·88	8·22
10	40	"		26·63	6·65
11	44	"		22·01	5·50
12	48	"		18·49	4·62
13	52	"		15·75	3·93
14	56	"		13·58	3 39
15	60	"		11·83	2 95
16	64	"		10·40	2·60
17	68	"		9·21	2·30
18	72	"		8·22	2 05
19	76	"		7·37	1·84
20	80	"		6·65	1·66
5	17·142	3½	112·99		28·24
6	20·571	"	94·47		23·61
7	24	"	79·13		19·78
8	27·428	"	66·65		16·66
9	30·857	"	56·54		14·13
10	34·285	"		47·55	11·88
11	37·714	"		39·29	9·82
12	41·142	"		33·02	8 25
13	44·571	"		28·13	7·03
14	48	"		24·26	6·06
15	51·428	"		21·13	5·28
16	54·857	"		18·57	4·64
17	58·284	"		16·45	4·11
18	61·714	"		14·67	3·66
19	65·142	"		13·17	3·29
20	68 571	"		11·88	2·97
5	15	4	162·77		40·69
6	18	"	139·00		34·75
7	21	"	118 54		29·63
8	24	"	101·34		25·33
9	27	"	87·02		21·75
10	30	"	75·15		18·78
11	33	"		64·92	16 23
12	36	"		54·55	13·63
13	39	"		46·48	11·62
14	42	"		40·07	10·01
15	45	"		34·91	8·72
16	48	"		30·68	7·67
17	51	"		27·18	6·79
18	54	"		24·24	6·06
19	57	"		21·76	5·44
20	60	"		19·63	4·90

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $W = 42{\cdot}8\frac{D^{3{\cdot}76}}{L^2}$.	Safe weight in tons.
5	13 333	$4\frac{1}{2}$	222·17		55 54
6	16	"	193·21		48·30
7	18·666	"	167 43		41·85
8	21·333	"	145·08		36·27
9	24	"	125·98		31·48
10	26·666	"	109·72		27·43
11	29·333	"	96·27		24·06
12	32	"	84·94		21 23
13	34·666	"		72 38	18·09
14	37·333	"		62 41	15 60
15	40	"		54·36	13·59
16	42·666	"		47·78	11·94
17	45·333	"		42·32	10·58
18	48	"		37·75	9·43
19	50·666	"		33 88	8 47
20	53·333	"		30 58	7·64
5	12	5	291·07		72·76
6	14·4	"	257·10		64·27
7	16 8	"	225·94		56·48
8	19·2	"	198·22		49·55
9	21·6	"	174·02		43·50
10	24	"	153·12		38·28
11	26·4	"	135 20		33·80
12	28 8	"	119·80		29 95
13	31·2	"	106 64		26·66
14	33·6	"		92·74	23·18
15	36	"		80·79	20·19
16	38·4	"		71·01	17·75
17	40 8	"		62 90	15·72
18	43·2	"		56·10	14·02
19	45·6	"		50 35	12·58
20	48	"		45·44	11·36
5	10	6	456·78		114·19
6	12	"	413 58		103·39
7	14	"	372·00		93·00
8	16	"	333·14		83·28
9	18	"	298 21		74 55
10	20	"	266·78		66·69
11	22	"	238·95		59·73
12	24	"	214·45		53·61
13	26	"	192·95		48 23
14	28	"	174 09		43 52
15	30	"	157·56		39 39
16	32	"		140·95	35 23
17	34	"		124·86	31·21
18	36	"		111·37	27·84
19	38	"		99·95	24·98
20	40	"		90·21	22 55

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44{\cdot}34\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formula, $T = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
5	30	2	1	36·85		30·28	7 57	3·02
6	36	"	"	44·22	22·58		5·64	2·25
7	42	"	"	51·59	17·37		4 34	1·73
8	48	"	"	58 96	13·85		3·46	1·38
9	54	"	"	66·33	11·33		2 83	1·13
10	60	"	"	73·70	9·47		2·36	0·94
11	66	"	"	81 07	8 06		2 01	0·80
12	72	"	"	88 44	6·95		1 73	0 69
13	78	"	"	95·81	6·06		1 51	0·60
14	84	"	"	103·18	5·34		1·33	0 53
15	90	"	"	110·55	4·75		1·18	0·47
16	96	"	"	117·92	4·26		1·06	0·42
17	102	"	"	125 29	3·84		0 96	0·38
18	108	"	"	132·66	3·48		0·87	0·34
19	114	"	"	140·03	3·18		0·79	0·31
20	120	"	"	147·40	2·91		0·72	0 29
5	20	3	2	61·42		82·51	20·62	8·25
6	24	"	"	73·71		68·32	17 08	6·83
7	28	"	"	85·99		57·26	14·31	5·72
8	32	"	"	98·28	48·73		12·18	4·87
9	36	"	"	110·56	39·88		9·97	3·98
10	40	"	"	122·85	33·34		8 33	3·33
11	44	"	"	135 13	28·35		7·08	2·83
12	48	"	"	147 42	24·45		6·11	2·44
13	52	"	"	159 70	21·34		5·33	2·13
14	56	"	"	171·99	18·81		4·70	1·88
15	60	"	"	184 27	16·73		4·18	1·67
16	64	"	"	196 56	14·99		3·74	1·49
17	68	"	"	208 84	13·49		3·37	1·34
18	72	"	"	221·13	12·27		3·06	1·22
19	76	"	"	233·41	11·20		2·80	1·12
20	80	"	"	245 70	10·26		2·56	1 02
5	15	4	3	85·99		149·60	37·40	14·96
6	18	"	"	103 19		128·79	32·19	12·87
7	21	"	"	120·39		111·37	27·84	11·13
8	24	"	"	136·59		96·88	24·22	9·68
9	27	"	"	154 79		84·84	21·21	8·48
10	30	"	"	171 99		74·79	18 69	7·47
11	33	"	"	189·18	66·04		16·51	6·60
12	36	"	"	206·38	56·96		14·24	5 69
13	39	"	"	223·58	49·71		12·42	4·97
14	42	"	"	240·78	43·83		10 95	4 38
15	45	"	"	257·98	38·98		9·74	3·89
16	48	"	"	275·18	34·93		8·73	3·49
17	51	"	"	292·38	31·50		7·87	3·15
18	54	"	"	309·58	28 59		7·14	2·85
19	57	"	"	326·78	26·01		6·50	2·60
20	60	"	"	343 98	23·90		5·97	2·39

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Calculated breaking weight in tons from formula, $w = 44{\cdot}34\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formula, $T = \frac{bc}{b + \frac{2}{3}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
5	12	5	4	110·56		224·13	56·03	22·41
6	14·4	"	"	132·67		198·66	49·66	19·86
7	16·8	"	"	154·79		176·16	44·04	17·61
8	19·2	"	"	176·90		156·55	39 13	15·65
9	21·6	"	"	199·01		139·59	34·89	13·95
10	24	"	"	221 13		124·96	31·24	12·49
11	26·4	"	"	243·24		112 33	28·08	11·23
12	28·8	"	"	265·35		101 41	25·35	10·14
13	31·2	"	"	287·46		91·93	22·98	9·19
14	33·6	"	"	309 58	82·75		20·68	8 27
15	36	"	"	331·69	73·59		18·39	7·35
16	38·4	"	"	353 80	65 95		16·48	6·59
17	40·8	"	"	375·92	59·49		14 87	5·94
18	43·2	"	"	398·03	53·98		13·49	5 39
19	45·6	"	"	420·14	49·24		12·31	4·92
20	48	"	"	442·26	45·12		11 28	4·51
5	10	6	5	135·13		302·25	75·56	30 22
6	12	"	"	162·16		273 80	68 45	27·38
7	14	"	"	189·18		247·60	61·90	24·76
8	16	"	"	216·21		223·91	55 97	22·39
9	18	"	"	243·24		202·74	50·68	20·27
10	20	"	"	270 27		183·94	45·98	18·39
11	22	"	"	297·29		167·29	41·82	16·72
12	24	"	"	324·32		152·58	38·14	15·25
13	26	"	"	351 35		139·57	34·89	13·95
14	28	"	"	378·37		128 04	32·01	12·80
15	30	"	"	405·40		117·82	29·45	11·78
16	32	"	"	432·43		108·72	27·18	10·87
17	34	"	"	459·45	98·97		24·74	9·89
18	36	"	"	486·48	89·81		22·45	8·98
19	38	"	"	513 51	81·92		20 48	8·19
20	40	"	"	540·54	75·08		18·77	7·50
8	10¾	9	8	334·15		449·65	112·41	44·96
10	13½	"	"	417·69		392 96	98·24	39·29
12	16	"	"	501·22		343·17	85·79	34·31
14	18¾	"	"	584·76		300·38	75 09	30·03
16	21½	"	"	668·30		263·99	65 99	26 39
18	24	"	"	751·84		233·16	58·29	23·31
20	26¾	"	"	835 38		207·02	51·75	20·70
8	8	12	11	450·84		687·29	171·82	68 72
10	10	"	"	563·55		623 61	155·90	62·36
12	12	"	"	676·26		563·51	140·87	56·35
14	14	"	"	788·97		508 43	127·10	50 84
16	16	"	"	901·68		458·85	114·71	45·88
18	18	"	"	1014·39		414·71	103·67	41·47
20	20	"	"	1127·10		375·64	93 91	37·56

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formulæ, $b = 44{\cdot}34\,\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$ $Y = \frac{bc}{b + \frac{2}{3}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
8	6 6-7	14	12½	781·33	1245·02	311·25	124 50
9	7 5-7	"	"	879·00	1195·69	298·92	119·56
10	8 4-7	"	"	976·67	1146·57	286·64	114·65
11	9 3-7	"	"	1074·33	1098·19	274·54	109·81
12	10 2-7	"	"	1172·00	1050·93	262·73	105·09
13	11 1-7	"	"	1269 67	1005·07	251·26	100·50
14	12	"	"	1367 33	960·82	240·25	96·08
15	12 6-7	"	"	1465·00	918 32	229·58	91·83
16	13 5 7	"	"	1562 67	877·64	219·41	87·76
17	14 4-7	"	"	1660·33	838·81	209·70	83·88
18	15 3-7	"	"	1758·00	801·87	200·46	80·18
19	16 2-7	"	"	1855 67	766·73	191·68	76·67
20	17 1-7	"	"	1953·34	733·40	183 35	73·34
21	18	"	"	2051·00	701 81	175·45	70·18
22	18 6-7	"	"	2148 67	671·88	167·97	67·18
23	19 5-7	"	"	2246·34	643 55	160·88	64·35
24	20 4-7	"	"	2344 00	616·75	154·18	61·67
25	21 3-7	"	"	2441·67	591·39	147·84	59·13
26	22 2-7	"	"	2539·34	567·39	141 84	56 73
27	23 1-7	"	"	2637·00	544·68	136 17	54·46
28	24	"	"	2734·67	523·20	130 80	52·32
29	24 6-7	"	"	2832·34	502·86	125·71	50·28
30	25 5-7	"	"	2930·01	483 59	120 89	48·35
8	6 2-5	15	13½	840·30	1366·04	341 51	136 60
9	7 1-5	"	"	945·34	1316·52	329·13	131·65
10	8	"	"	1050·38	1266·86	316·71	126·68
11	8 4-5	"	"	1155·41	1217·62	304·40	121·76
12	9 3-5	"	"	1260 45	1169·18	292 29	116·91
13	10 2-5	"	"	1365·49	1121·86	280·46	112·18
14	11 1-5	"	"	1470·43	1075·91	268·97	107·59
15	12	"	"	1575·47	1031·49	257·87	103·14
16	12 4-5	"	"	1680·60	988 72	247·18	98·87
17	13 3-5	"	"	1785·64	947·66	236 91	94·76
18	14 2-5	"	"	1890·68	908 38	227 09	90 83
19	15 1-5	"	"	1995·72	870·82	217·70	87·08
20	16	"	"	2100·76	835·00	208·75	83·50
21	16 4-5	"	"	2205·79	800·90	200·22	80·09
22	17 3-5	"	"	2310·83	768 44	192·11	76·84
23	18 2-5	"	"	2415·87	737·59	184·39	73·75
24	19 1-5	"	"	2520·91	708·28	177·07	70·82
25	20	"	"	2625·95	680 44	170·11	68·04
26	20 4-5	"	"	2730 98	653 99	163·49	65·39
27	21 3-5	"	"	2836·02	628·87	157·21	62·88
28	22 2-5	"	"	2941·06	605 05	151 26	60·50
29	23 1-5	"	"	3046·10	582·41	145 60	58 24
30	24	"	"	3151·14	560·91	140 22	56 09

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formulæ, $b = 44{\cdot}34\,\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{l^{1{\cdot}7}}$ $Y = \frac{be}{b + 2c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
8	6	16	14½	899·27	1487·02	371·75	148 70
9	6 3-4	"	"	1011·68	1437·50	359 37	143·75
10	7 1-2	"	"	1124·09	1387·54	346·88	138·75
12	9	"	"	1348 90	1288 34	322·08	128·83
15	11 1-4	"	"	1686·13	1146·46	286 61	114·64
20	15	"	"	2248·18	939·67	234·91	93·96
8	5 11-17	17	15½	958·24	1607 94	401·98	160 79
10	7 1-17	"	"	1197 80	1508·47	377·11	150·84
12	8 8-17	"	"	1437·36	1408·20	352 05	140·82
15	10 10-17	"	"	1796 70	1262·90	315·72	126·29
20	14 2-17	"	"	2395·60	1047·01	261·75	104·70
8	5 1-3	18	16½	1017·20	1728·69	432·17	172·86
10	6 2-3	"	"	1271·50	1629·46	407·36	162·94
12	8	"	"	1525·80	1528·49	382·12	152·84
15	10	"	"	1907·25	1380·42	345·10	138·04
20	13 1-3	"	"	2543·00	1156 53	289·13	115·65
10	5 15-21	21	19	1965·50	2616·54	654·13	261·65
15	8 12-21	"	"	2948·25	2277 34	569·33	227·73
20	11 9-21	"	"	3931·00	1956·15	489·03	195·61
10	5	24	22	2260·20	3099·32	774·83	309·93
15	7 1-2	"	"	3390·30	2758·42	689·60	275·84
20	10	"	"	4520·40	2421·21	605 30	242·12

Having brought this series to a conclusion, I purpose in a succeeding series giving the strength of timber pillars.

On the Preparation of Artificial Coloring Matters with the Products Extracted from Coal Tar. By M. E. Kopp.

From the Lond. Chemical News, Nos. 40 and 42.

(Continued from page 184.)

Before rectification the oils are agitated for an hour with concentrated sulphuric acid, the light with 5 and the heavy with 10 per cent. They are then allowed to rest for 24 or 36 hours, for the acid and impurities to deposit. The oil is then separated and washed once or twice with water, and afterwards with a solution of caustic soda sp. gr. 1·382. For the lighter, 2 per cent. of the soda solution will be enough, but the heavier will require 6 per cent. When so purified, the light oil is rectified by distillation with a current of steam. The condensed product, having a mean density of ·815 to ·820, is the benzole of commerce.

The heavy oil is distilled without the assistance of a current of steam. The condensed product has a mean density of ·860, is of a

clear yellowish color, similar to that of Madeira wine, and has the disagreeable odor of sulphur compounds, formed by the action of the sulphuric acid. This may be destroyed by shaking the oil before distillation with a solution of sulphate of iron, or after distillation with the addition of some caustic soda to the sulphate of iron. A blackish deposit of sulphide of iron is formed and the oil loses its bad odor.

Paraffine and the heavier mineral oils which drain from the paraffine are purified in the same way by means of sulphuric acid, which is sometimes combined with oxidizing agents, such as bichromate of potash, peroxide of manganese, manganate of potash, &c., and subsequent washing with caustic soda. After the action of the acid and alkali, paraffine is sometimes rectified by a second distillation, but more frequently the purification is completed by a second treatment with sulphuric acid, followed by a careful washing, after which the paraffine is mixed with 1 per cent. of stearic acid, and treated with the caustic soda. The alkali by saponifying the stearic acid forms soapy flocculi, which envelope the impurities, and the melted paraffine is rendered perfectly limpid.

The acid and alkaline residues of the above purifying processes are generally thrown away, but in them are found the principles which may be utilized for the production of the coloring matters. The sulphuric acid, for example, must combine with all the alkaline compounds, such as aniline, quinoline, toluidine, cumidine, &c.; while the caustic soda must unite with the acid principles, like phenol, creosote, and rosolic acid. Vohl* has already proposed to extract phenol and creosote from the alkaline solution by supersaturating it with the acid solution, decanting the oily layer which separates, and rectifying it over a naked fire. A more rational process, according to the author, would be the following:—Collect all the acid and alkaline liquors, and determine how much of the acid liquor would be sufficient to saturate a given volume of the alkaline. This being known, mix the alkaline solution with twice the quantity of acid liquor necessary to saturate it. If the two be mixed rapidly, sufficient heat will be developed to raise the mixture almost to the boiling-point, and a concentrated solution of bisulphate of soda will be formed, which retains in solution the bisulphates of aniline and toluidine, while the phenol and creosote easily separate in form of a brown oil. This oil may be separated while the mixture is still warm, and rectified. A light neutral oil first passes, and afterwards the phenol and creosote distil almost pure.

The solution containing the acid sulphates of soda and the organic bases yields on cooling crystals of bisulphate of soda, which may be collected on a filter. The acid liquor not used to saturate the soda solution may then be added from the mother-liquor from the crystals, and the whole heated to 60° or 80° C. Chalk or milk of lime is then added to partial saturation, the sulphate of lime is allowed to deposit, and the liquor is concentrated. Finally, the concentrated acid sulphates are introduced into an iron still, and an excess of quicklime is added. Sulphate of lime and some sulphate of soda are formed, the

* *Journal fur Prakt. Chem.* Bd. lxxv. s. 295.

organic bases are set at liberty, and on heating they pass over and condense with some water. If the quantity of water be sufficient to hold the bases in solution, the distilled aqueous solution must be saturated with hydrochloric acid and evaporated, first over a naked fire and then over a water bath, almost to dryness. The residue placed in a retort is mixed with an excess of quicklime and distilled, when an oily liquid is obtained, which consists principally of aniline, toluidine, and quinoline, sufficiently pure for the preparation of the coloring matters.

We shall now notice successively the compounds from which the coloring matters may be formed, and the coloring matters themselves, describing the most advantageous and best known process for obtaining them.

1. *Aniline.*—Unverdorben first discovered aniline among the products of the dry distillation of indigo in 1826. As it formed crystallized salts with acids, he gave it the name of *crystalline*. In 1840, Fritsche made anthranilic acid by introducing finely powdered indigo into a hot and strongly concentrated solution of caustic potash. One of the most remarkable properties of this acid is its splitting up into carbonic acid and aniline when distilled with quicklime.

$$\underbrace{C_{14}H_7NO_4}_{\text{Anthranilic Acid.}} + 2\,CaO = \underbrace{C_{12}H_7N}_{\text{Aniline.}} + 2\,(CO_2.CaO).$$

Erdmann first observed that aniline was identical with the crystalline of Unverdorben. Hoffmann afterwards showed that to prepare aniline it was not necessary to make anthranilic acid, but that it sufficed to distil indigo directly with hydrated caustic potash, the aniline being formed in consequence of a real oxidation of the indigo.

Isatine, a product of the oxidation of indigo by weak nitric acid, also furnishes aniline on distillation with caustic potash. Runge, 1837, first announced the existence of three volatile bases in coal tar, which he named respectively kyanol, leukol, and pyrrol. Hoffmann subsequently demonstrated that kyanol was identical with aniline, and later he proved that leukol was identical with quinoline, a base which Gerhardt had obtained by distilling the cinchona alkaloids with mineral alkalies. Another very remarkable method of forming aniline is based upon the action of reducing bodies on nitro-benzole. Zinin, by saturating an alcoholic solution of nitro-benzole with ammonia, and then passing sulphuretted hydrogen as long as any deposit of sulphur was formed, obtained an organic alkali which he called benzidam, but which was afterwards proved to be aniline.

$$\underbrace{C_{12}H_5NO_4}_{\text{Nitrobenzole.}} + 6\,HS = C_{12}H_7N + 4\,HO + 6\,S.$$

Bechamp showed that the reduction could be effected equally well by means of ferrous acetate or acetic acid and iron.

$$C_{12}H_5NO_4 + 6\,Fe + H_2O_2 + 6\,\bar{A} = C_{12}H_7N + 6\,(FeO\bar{A}).$$

Before this, however, Hoffmann had shown that nitro-benzole might be converted into aniline by the action of zinc and hydrochloric acid.

Lastly, Wöhler has discovered that nitro-benzole may be reduced and transformed into aniline by digestion and distillation with a solution of arsenious acid in an excess of caustic soda.

Amongst other methods of producing aniline we quote the following: Phenol and ammonia placed in a stout tube sealed and exposed for a long time to a high temperature from aniline.

$$\underbrace{C_{12}H_6O_2}_{\text{Phenol.}} + NH_3 = C_{12}H_7N + 2HO.$$

According to Hoffmann and Muspratt, nitro-toluene and salicylimide, two bodies isomeric with anthranilic acid, furnish aniline when heated to redness.

$$\underbrace{C_{14}H_7NO_4}_{\text{Nitrotoluene.}} = C_{12}H_7N + 2CO_2.$$

Of all the methods, however, two only appear to serve as industrial processes:

1. Extraction from coal tar.
2. Reduction of nitro-benzole.

Extraction of Aniline from Coal Tar.—The method which appears to be the most rational, and which deserves to be tried, would consist in treating the tar as condensed in gas works, with hydrochloric or sulphuric acid, diluted with 3 or 4 times its volume of water. Mechanical means for effecting the intimate mixture of the tar with the acid might be easily contrived, but in the absence of any special contrivance, the end may be attained by half filling a barrel with the tar, adding one-fifth or one-sixth its volume of acid, and rolling and shaking the barrel until the acid has taken up all the bodies with which it is able to combine; the whole might then be run into a cistern, where by degrees the watery liquid would separate from the tar. The same acid liquid might be used over and over again, until the bases had nearly saturated the acid. A very impure aqueous solution would thus be obtained, but containing the hydrochlorates or sulphates of ammonia, and all the other organic bases contained in the tar, such as aniline, quinoline, pyrrol, picoline, pyrrhidine, lutidine, toluidine, cumidine, &c. By evaporating this solution almost to dryness, and then distilling with an excess of milk of lime, the bases would be set at liberty. Ammonia, as the most volatile, would be disengaged first, and might be condensed apart, and by raising the temperature higher and higher the other bases would be disengaged. Aniline would be found among the liquids distilling between 150° and 250° C.

The manipulation of the tar, however, is an extremely disagreeable operation, and presents many difficulties; it is therefore preferable, in most cases, to distil the tar first, and only operate on the most pure and limpid distilled oils.

Aniline, because of its high boiling-point, is never met with in the light and volatile liquids which first distil from tar. The most of it is found in those which distil between 150° and 230° C. These, according to Hoffmann, contain about 10 per cent. of organic bases, mostly

aniline and quinoline. The oils which distil above 250° contain mostly quinoline, and very little aniline.

The following is Hoffman's process for extracting the two bases from the oils and separating them. The oil is agitated strongly with commercial hydrochloric acid. The mixture is then allowed to rest for 12 or 14 hours, and the oil is separated from the acid; the latter is treated again with fresh quantities of oil until it is nearly saturated. The still acid solution of the hydrochlorates is filtered through linen or wetted filtering paper, to retain the greater part of the oil mechanically mixed with the watery solution; it is then placed in a copper still, and supersaturated with an excess of milk of lime. At the moment of saturation an abundance of vapors are given off, and the head must be quickly fixed on the still. Heat is now applied, so as to obtain a quick and regular ebullition.

The condensed product is a milky liquid, with oily drops floating on it. The distillation is carried on as long as the vapor has the peculiar odor of the first part distilled, or the condensed product gives the characteristic reaction of aniline with chloride of lime.

The milky liquid is now saturated with hydrochloric acid; it is then concentrated in a water bath; and lastly, decomposed in a tall narrow vessel by means of a slight excess of hydrate of potash or soda. The bases set free, unite, and form an oily liquid, which floats on the alkaline solution. This is removed with a pipette and rectified. The rectified product is aniline, sufficiently pure for industrial purposes, especially if we set aside the part distilling above 200° or 220°, which is principally composed of quinoline.

To obtain aniline chemically pure, the neutral oils forming part of the oily layer must be completely removed. This is done by dissolving the whole in ether, and adding dilute hydrochloric or sulphuric acid, which combines with and separates the bases, and leaves the oils in solution in the ether. The acid solution is then decanted, decomposed with potash, and submitted to careful fractional distillation. If the products are gathered separately in three parts, the first will contain ammonia, water, and some aniline; the second will be pure aniline; while the third portion will contain mostly quinoline. An alcoholic solution of oxalate acid is now added to the impure aniline, which precipitates oxalate of aniline, as a mass of white crystals, which are washed with alcohol, and then pressed. The salt is then dissolved in a small quantity of water, to which a little alcohol is added. From this solution the oxalate crystallizes in stellated groups of oblique rhomboidal prisms. These crystals are decomposed by a caustic alkali, to set free the aniline, and when this is distilled, water at first passes, then water charged with aniline, and lastly, at 182° C. chemically pure aniline.

Artificial preparation of Aniline by the reduction of Nitro-benzole.—This process, which constitutes one of the most curious and important reactions of organic chemistry, allows us to obtain aniline in any quantity. It is not difficult to prepare, but certain precautions are necessary when operating on a large scale.

The process may be subdivided into three distinct operations.

1. *Preparation of Benzole.*
2. *Transformation into Nitro-benzole.*
3. *Reduction of Nitro-benzole to form Aniline.*

1. *Preparation of Benzole.*—The only process we have space to notice is that by which benzole is obtained on a large scale, viz: the extraction from coal-tar, or from the first products of the distillation of coal-tar, light oil, or crude naphtha.

The manufacturer who wishes to distil tar in order to procure the largest amount of benzole, should choose a light fluid tar, and preferably one distilled from boghead or cannel coal. To form a comparative estimate of the value of different tars, the following experiment may be performed:—About 20 pints of the tar are distilled until the vapors, instead of condensing into a liquid, furnish a product which, on cooling, becomes solid, or of a buttery consistence. By carefully observing when the condensed oil becomes heavier than the water, and measuring the volume of the lighter oils which float on the surface of the water, and then comparing the volumes, we are enabled to estimate with tolerable accuracy the value of the tar. Of course, that which yields the largest amount of light oil is the best.

Some account of the process of distillation was given at pages 124 and 148 of this volume, to which we refer the reader, and also to the paper by Mr. Mansfield, in the *Quarterly Journal of the Chemical Society*, i. p. 244.

Crude naphtha, or the benzole of commerce, is generally a yellow or brown liquid, having a density varying from ·90 to ·95; it usually contains, besides benzole, some of the homologues of benzole, toluol, cumol, and cymol. It is impossible to separate these bodies by an ordinary process of rectification; for although the boiling point of toluol is 108° or 109°, and that of cumol 143° or 145°, their vapors are, so to say, dissolved in the vapor of benzole, and are carried over and condense together. Their presence, however, need not interfere with the preparation of nitro-benzole and aniline.

The benzole found in commerce is at times very impure; some, indeed, has been met with containing but a trace of real benzole. Such an article is generally the result of the distillation of bituminous schists or asphaltum; and, besides hydrocarbons belonging to another series than that of benzole, it generally contains a small amount of oxygenated products, and consequently cannot be advantageously used in the preparation of aniline. It is therefore important to be able readily to detect benzole in a mixture of other oils. For this purpose we may avail ourselves of the facility with which true benzole is converted into nitro-benzole and then into aniline by the action of nascent hydrogen.

The following is Hoffmann's method:—A drop of benzole is heated in a small test-tube, with fuming nitric acid, to convert it into nitro-benzole. A good deal of water is then added, to precipitate the nitro-benzole in small drops, which must be taken up by ether. The etherial solution is then poured into another small tube, and equal volumes of

alcohol and dilute hydrochloric acid are added; a few fragments of granulated zinc are then dropped in. In about five minutes sufficient hydrogen will have been disengaged to produce aniline, which will be found combined with the acid. The liquid is supersaturated with an alkali and shaken with ether, which dissolves the aniline set free. A drop of this etherial solution allowed to evaporate on a watch glass, and mixed after the evaporation of the ether with a drop of a solution of hypochlorite of lime, will show the violet tints which characterize aniline. The operations may be executed very rapidly, and without any difficulty.

Properties of Benzole.—At the ordinary temperature benzole is seen in the form of a colorless very fluid liquid, of an agreeable(?) odor, and having the specific gravity ·85° at 15° C. At a very low temperature it crystallizes or forms a mass like camphor, which melts at 5°. Its boiling-point is between 80° and 81°, and it distils without undergoing any change. It is nearly insoluble in water, to which, however, it imparts its peculiar odor; it is very soluble in wood-spirit, ether, alcohol, the essential and the fatty oils; and it easily dissolves camphor, wax, fatty matters, india-rubber, gutta-percha, and a great number of resins. Among the last, those which are least soluble in it are shellac, copal, and animi. It is very inflammable, and burns with a brilliant smoky flame. Hydrogen gas passed through it, and charged with its vapor, burns with a very clear, luminous flame.

Chlorine and bromine convert benzole into the terchloride and terbromide of benzole. In direct solar light the change takes place very quickly. Concentrated sulphuric acid dissolves benzole, and when the mixture is gently heated, a copulated acid, sulpho-benzylic acid is formed, $C_{12}H_6S_2O_6$, the hydrogen of which may be replaced by metals. As this acid is soluble in water, we see that in purifying rough benzole with sulphuric acid it is necessary to avoid using an excess of the acid, and also heating the mixture. A solution of chromic acid does not act on benzole, and is therefore a good agent for the purification. Concentrated nitric acid converts benzole into nitro-benzole, to the manufacture of which we next proceed.

(To be Continued.)

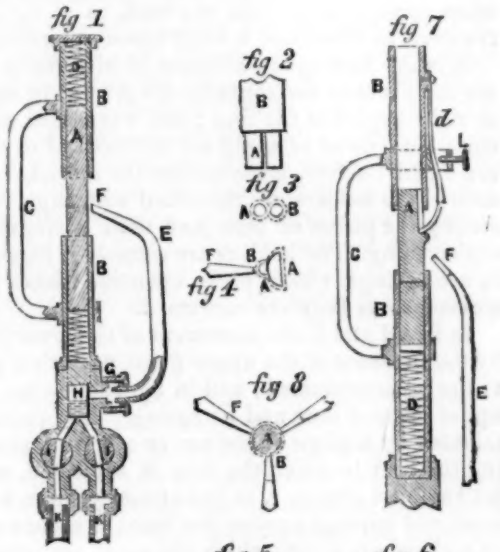
Specification of a Patent granted to William Prosser *and* Henry John Standly, *for Improvements in Apparatus employed in the production of Light.*—Dated 25th October, 1860.

From Newton's London Journal, July, 1861.

These improvements are applicable where oxygen and hydrogen gases, or their compounds, are employed to produce light by their ignition on a surface of lime or other suitable material; and the improvements relate to the use of two or more pieces of lime or other material abutting against each other and pressed in opposite directions towards the jet or jets of flame which impinge upon them,—the one being used as an abutment for the other. When more than two pieces of lime or other material are used, they should be caused to converge or other-

wise move towards a common centre, each piece being pressed forward by a spring or weight, or other convenient means, so as to keep the pieces of lime or other material in contact with each other at or about the place where the jet or jets of flame impinge upon them; and these pieces of lime or other material are placed in tubes, cases, or holders, and advanced so as to cause the pieces of lime to move towards each other as they are consumed or dissipated by the action of the jet or jets of flame, and thus they are kept in contact at or about the place where the jet or jets of flame strike.

Figure 1 shows, in vertical section, an arrangement for using two pieces of lime (that material being preferred) either in the same line, or angularly with respect to each other. The pieces of lime are pressed towards each other by springs, which prevent them from being dislodged from the holders. Figs. 2, 3, and 4 show arrangements in which the lime is similarly moved forward by springs, the pieces of lime being of various forms of section.



Figs. 5 and 6 show an arrangement by which several pieces of lime may be disposed round a jet, either in a flat plane or angularly to each other, and converging towards the jet.

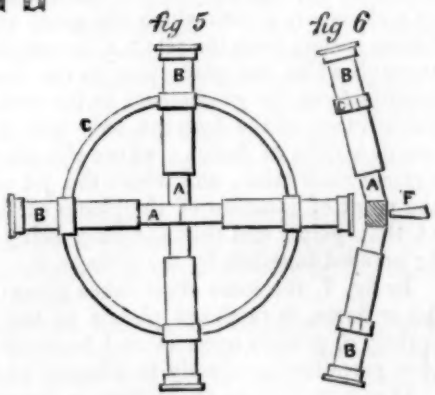


Fig. 7 shows a modification of the foregoing, in which the resistance to the undue advance of the piece or pieces of lime is effected by the pressure of a spring acting against the surface of the lime, instead of against the end of an opposing piece of lime; the object sought to be obtained, in all cases, being to prevent the lime being moved otherwise than as it is consumed.

Fig. 8 is a transverse section of a piece or pieces of lime, with several jets disposed round it, so as to illuminate the entire space surrounding the lamp.

In applying these lamps to various purposes, the vertical or horizontal arrangement will be adopted, as may be best suited to the object; as, for instance, when a lamp is required to illuminate the space in front of it, the vertical arrangement is the most convenient, and when the space beneath the lamp is required to be illuminated, the horizontal arrangement is preferable. Fig. 7, with a single jet, is a very convenient form of lamp for illuminating the space in front of it; and when three or more jets are used, as at fig. 8, it is applicable when required to illuminate a large space around it.

A, is the lime upon which the jet of flame is made to impinge. When the lime is used horizontally, the jet will be more conveniently applied at right angles to the lime; and when used vertically, it will be found more convenient to apply the jet inclined to the lime (as in fig. 1). B, are metal holders, made to suit the sectional form of the lime. The ends of the holders are furnished with caps, for the convenience of inserting the pieces of lime (and their springs) when the lamp requires replenishing. The holders are connected together by a bar or frame, C. D, are springs, which press upon the pieces of lime, and cause their movement as they are consumed.

In figs. 1 and 5, the movement of the lower piece of lime is prevented by the pressure of the upper piece, until that portion which is opposite to the jet is consumed; and in fig. 7, a spring, *d*, is substituted for the upper piece of lime and its spring. The point of the spring, *d*, is terminated by a piece of iridium or other material capable of withstanding the heat to which the lime is subjected, without melting. E, is a jet having a nipple, F, at its extremity, from which the combined gases issue and impinge against the lime; it is connected by an union cap, G, to a chamber, H, into which the gases are introduced and there mixed before issuing from the jet; I, I, are regulating cocks (one for each gas), through which the gases pass to the chamber, H; and K, K, are pipes leading from the gas holders to the cocks, I, I. It will be obvious that the advance of the lime can only take place when the abutting points are in a state of fusion: where the pieces of lime are caused to abut against each other, and where the jet of flame is caused to act upon the point of junction of the pieces of lime, the fusion will take place at that point, and thus the lime, being in a soft or plastic state, will be pressed together by the springs, D.

In fig. 7, the same effect takes place: the lime, being fused by the jet or flame, is rendered plastic at the place where the point of the spring, *d*, presses upon it and becomes embedded in it. The lime is thus permitted gradually to advance to or before the jet of flame.

It will be obvious that unless a progressive movement be given to the lime, the light will gradually lose its brilliancy as the space between the point of the jet and the surface of the lime becomes increased. A chamber, H, is provided between the regulating cocks and the jet, in which from twelve to twenty wire gauze washers are placed,

through which the gases pass and become thoroughly mixed, and through which the regurgitation of the flame is effectually prevented.

The patentees claim, "the arrangement, as herein described, of the pieces of lime or other material, and the mode of regulating their movement as they are consumed and rendered unfit for the purpose of producing a uniform and brilliant light, by the ignition of oxygen and hydrogen gases or their compounds thereon."

New Maximum Thermometer.

This instrument, contrived by M. Doulcet and constructed by M. Baudin, is nothing more than the ordinary minimum alcohol thermometer; except that the glass index has but one bulb in place of two, and terminates in a point at its outer end. When this instrument is hung vertically with the bulb uppermost, the index falls until the point touches the lower edge of the liquid: here it stops; now, if the liquid expands, the index will fall farther, but, if it contracts, the adhesion is not sufficient to lift the index, which remains in its place. It is said even to be very firm, so that severe jars will not displace it, and the best method of re-adjusting the instrument, is to warm the bulb until the liquid again reaches the point; the index is then easily moveable.—*Cosmos.*

On the Composition of Cast Iron and Steel. By M. E. Fremy.

From the London Chemical News, No. 77.

The phenomena determining the production of steel have always occupied the attention of chemists and manufacturers, but at the present moment the study of this question has assumed an exceptional importance. In fact, the construction of machines and the manufacture of fire-arms are extending the applications of steel, and necessitate its production as economically as possible, consistently with preserving its valuable properties. To resolve this problem, of so much interest to metallurgical industry, chemistry ought to throw fresh light on the theoretical questions relating to the production of steel, and to free manufacture from the uncertainty and empirical methods which retard its due development.

The theories hitherto proposed to explain the phenomena of steeling, are evidently inadequate to guide the metallurgist wishing to produce steel either by the cementation of iron by charcoal or by decarburetting cast iron by special puddling.

Thus, the influence of manganese and that of tungsten in the process of steeling is not easily explained. The utility of nitrogenized organic substances and certain saline matters in aiding solution, is denied by experienced metallurgists. Some are of opinion that the best quality of cemented steel is obtained by the action of carbon on pure iron; others, that cementation can take place only under the influence of the nitrogen of the air. In either case, theory does not tell us why certain irons yield the best steel, while others, to all appear-

ance as pure, produce a very inferior quality. It is well known that the difficulties in the fabrication of steel obtained by puddling are such as often to discourage the most skilful manufacturers.

This uncertainty in the methods of steeling is found likewise in the theories proposed for explaining the production of steel. Some chemists are of opinion that solid carbon acts directly on iron, penetrates the metal, and circulating in its mass, converts it into steel. Others, among whom Leplay and Laurent are conspicuous, believe that cementation is invariably owing to the action of a gaseous carburetted compound of iron. Laurent goes so far even as to say that in the cementation boxes the vapor of the volatilized carbon effects the acieration.

The action exercised on iron by cyanides widens the field of the theory of cementation. A familiar experiment in chemistry has been utilized in practice: it consists in converting iron into steel by heating it with an alkaline cyanide or ferrocyanide. And, again, M. Caron, in a recent and interesting communication to the Academy, states that cyanide of ammonium, which is formed in the cementation-boxes, acts on iron like alkaline cyanides and rapidly converts it into steel.

The papers published on the subject of acieration have, doubtless, enriched science with many new and important facts; above all, they have particularized the circumstances which appear to determine this process most readily, but they have thrown no new light on the theoretical questions relating to the chemical constitution of steel. The writers still aver that steel is a carburet of iron, which they place chemically between iron and cast iron.

My opinion as to the composition of steel differs entirely from those hitherto accepted. I hope to be able to prove that steel is not a carburet of iron, and that there exists a series of steels resulting from the combination of iron with metalloids, metals, and even with cyanuretted bodies.

I am not acquainted with a single unequivocal experiment tending to show that steel is a combination of pure carbon and iron. Minute proportions of foreign bodies, not always detectable by analysis, can modify the properties of iron. When it is proposed to study the action of pure carbon on iron, there are necessarily other bodies present besides those whose mutual action we desire to determine. Without referring to the impurities taken up from the crucible, there are the influence of the gases from the furnace, which penetrate the apparatus; the action of the atmospheric elements which the charcoal does not absorb; or the presence of the various substances contained in the charcoal itself,—all of which circumstances are wholly disregarded.

In an experiment with diamond-dust, which I shall presently state, the influence of foreign bodies have been equally unheeded.

I shall now recal the fact I have already submitted to the Academy, which is, that steel, when dissolved in acids, leaves a residue in no point resembling pure carbon, and which, by its properties and composition, is nearly allied to certain carburetted products; thus, both

synthetical and analytical experiments are far from proving that steel contains nothing but carbon and iron.

To determine the true constitution of steel, and to ascertain whether there does not exist a series of bodies differing in composition, as tungsten steel differs from that of charcoal, yet allied by certain common properties, I propose to submit iron to the action of all the bodies capable of influencing the phenomenon of acieration.

I think that nitrogen ought to take the first place in this examination. Such was the object of my last communication to the Academy.*

I have applied myself to free nitride of iron from the excess of metal it is capable of retaining, and to produce, as far as possible, a definite compound.

But in the nitration of iron, as in the carburation of this metal, there are different degrees. Before forming under the influence of nitrogen, the scales which come off, and which, according to my experiments, contain 9·5 per cent. of nitrogen, the general properties of the metal undergo profound modifications; while preserving a certain malleability, it becomes white and fibrous. The iron in this state is still metallic, but, nevertheless, is strongly nitrogenized. It is this nitrogenized iron which I submit to the Academy, and which has undergone the processes connected with steeling which I am about to describe.

Desiring to study the successive or simultaneous action of nitrogen and carbon on iron, I was first obliged to find out a simple and easily graduated method of carburation as certain as the process for the nitration of iron by ammonia.

The action of illuminating gas on iron possesses all these advantages. In fact, I have proved that if dry coal-gas is passed at red heat during two hours on iron, I obtain a very regular carburation, and the metal is converted into a grey cast iron, graphitic, very malleable, and in every way comparable to the best cast iron produced by wood charcoal. I present to the Academy a specimen of cast iron formed under these circumstances.

By employing ammonia and coal-gas, I possess two easily regulated processes, which enable me to study, either isolatedly or simultaneously, the action of ammonia and carbon on iron.

The result of my experiments is, that when iron is submitted to the action of coal-gas I obtain cast iron only; but when the carburetted gas is made to react on previously nitrogenized iron, the characteristics of steel are evident in the metallic compound. A very remarkable fact here appears, which is, that the properties of the steel in some measure depend on the quantity of nitrogen first imparted to the iron. If the nitration has not been carried on a sufficient time, the coal-gas, in acting upon iron, produces a body intermediate between steel and cast iron; if, on the contrary, the metal has undergone a sufficient degree of nitration, the gas produces a steel of magnificent grain. The specimens which I presented to the Academy were formed in this manner. I have thus been enabled to realize M. Despretz's anticipations, and to determine what influence nitride of iron exercises on the phenomena of steeling.

* Chemical News, Vol. iii. p. 276.

When, instead of making nitrogen and carbon react successively on the metal, I have passed a mixture of ammonia and lighting-gas on red-hot iron, the metal has immediately changed to steel, which varies with the relative proportions of the two gases.

In the experiments here described, I believe I have for the first time produced steel by means of the successive action of two gases on iron—one, ammoniacal gas, furnishing nitrogen; the other, lighting-gas, furnishing carbon; and what appears to me to make the steel thus obtained still more interesting is, that with it cementation is no longer effected with wood charcoal, but with coal-gas. I ask metallurgists whether these experiments, which, in a theoretical point of view, throw light on the phenomenon of cementation, will not one day be practically utilized. Would it not be a curious circumstance in the cementation of iron were wood charcoal superseded by the products of the distillation of coal?

These facts establish positively the important part nitrogen plays in the phenomena of steeling. It remained for me to ascertain whether nitrogen, evidently a cementing agent, remains in the metallic compound, or whether its only use is to present carbon to the iron in a state favorable to chemical combination.

To resolve this interesting question, I submitted steel, obtained with ammonia and lighting gas, to the influence of the agent which could prove the presence of nitrogen in steel with the greatest nicety, viz: pure and dry hydrogen.

By heating in hydrogen some steel prepared in my laboratory, I immediately detected the presence of nitrogen in this metallic compound; for during the whole of the experiment it disengaged considerable quantities of ammonia.

After thus re-finding nitrogen in steel obtained by the action of ammonia and lighting-gas on iron, it became interesting to submit ordinary steel to the same proofs, and to ascertain whether these metallic compounds are equally nitrogenized.

To this end I have operated on steels of various sorts, all in high commercial estimation. My experiments were made successively on Jackson's French, Huntsmann's English, and Krupp's German steel.

(To be Continued.)

On the Amounts of Lead contained in some Silver Coins. By Messrs. Charles W. Eliot and Frank H. Storer.

From the London Chemical News, No. 77.

From our experiments upon the impurities of commercial zinc,* we found that this metal almost invariably contains lead. In the preparation of silver at the United States Mint, zinc is used for the purpose of reducing chloride of silver,† and a sample of zinc similar to that

*Memoirs of the American Academy, 1860 [N. S.], viii. 57.

†Booth and Morfit's Smithsonian Report on Recent Improvements in the Chemical Arts. (Washington, 1851.) p. 56. Compare Wilson's Report on the New York Industrial Exhibition, in *Dingler's Polyt. Journal*, 1855, cxxxv. 119.

used at the Mint, which we examined, yielded half of one per cent. of lead. The question naturally suggested itself whether lead might not thus find its way into American silver coin, and to determine this point, we have analyzed several American coins, as specified in the following table. For the sake of comparison, we subsequently examined the other coins therein enumerated.

(1) Kind of Coin.	(2) Weight of Coin taken.	(3) Weight of BaO, SO_3 found.	(4) Weight of Pb corresponding to SO_3 in the BaO, SO_3 of column (3).	(5) Corresponding per cent. of Lead in the Coin.	(a)* Weight of PbO, SO_3 found.	(b)* Corresponding weight of Pb.	(c)* Corresponding per cent. of Lead in the Coin.
	Grms.	Grms.			Grms.		
1 American half-dollar of 1824, . .	13·2936	0·0465	0·0412	0·3100	0·0480	0·0327	0·2462
20 American five-cent pieces of 1853, .	24·2630	0·0571	0·0507	0·2090	0·0555	0·0379	0·1560
10 American five-cent pieces of 1854, . .	12·1980	0·0314	0·0278	0·2282	0·0270	0·0185	0·1513
2 American twenty-five cent pieces of 1858,	12·4097	0·0322	0·0286	0·2305	0·0310	0·0273	0·2200
"Fine silver,"† from the U. S. Assay Office in New York, 1860, .	30·6405	0·0557	0·0494	0·1611	0·0655	0·0447	0·1457
1 Spanish dollar of 1793, Carolus IV., .	27·0130	0·0170	0·0151	0·0558	0·0129	0·0088	0·0326
1 Mexican dollar of 1829,	27·2265	0·0127	0·0118	0·0434	—	—	—
2 English shillings of 1816,	10·4597	0·0537	0·0507	0·4847	0·0590	0·0422	0·3846
1 French five-franc piece of 1852, Napoleon III.,	24·9725	0·1135	0·1069	0·4282	0·1296	0·0886	0·3546

On the supposition that the zinc used in the reduction of the silver is the source of the lead in the American coin, it is easy to calculate the amount of lead which would thus find its way into the coin, since the quantity of zinc used in reducing a given weight of silver, and the per cent. of lead which that zinc may be expected to contain, are both known quantities. Professor Booth‡ says that an excess of zinc is required to insure total and rapid reduction, and Wilson§ states that two equivalents of zinc are used, in practice, for each equivalent

*Columns (a), (b), and (c), contain the results of a supplementary series of experiments, made merely to control the results given in columns (4) and (5). (*Vid. infra.*)

†The solution of this fine silver in nitric acid became blue when neutralized with ammonia. The filtrate from the mixed precipitate of sulphate of lead and gold contained a decided trace of copper and a fainter trace of iron. The solution of sulphate of soda, from which the sulphuric acid of col. (3) was determined, exhibited a slightly yellowish-light-brown color, nothing similar to which occurred in any of the other experiments. A slight black residue remained when this silver was dissolved in nitric acid, and a trace of gold was detected in the residue.

‡ *Loc. cit.* § *Loc cit.*

of silver. Our memoir, already cited, gives the per cents. of lead found in two specimens of Vieille Montagne zinc. The standard of the American silver coin is ·9 silver and ·1 copper, and the weight of fifty cents' worth of this alloy, in either half-dimes, dimes, quarters, or a half dollar, has been 192 grains = 12·433 grammes, since the year 1853.*

Fine silver in the half-dollar, .	11·190 grams.
Zinc used in reducing 11·19 grams. silver, .	6·742 "
Amount of lead in 6·742 grams. zinc, if the zinc contains 0·292 per cent. of lead, † .	0·0197 "
Amount of lead in 6·742 grams. zinc, if the zinc contains 0·494 per cent. of lead,† .	0·0333 "

If zinc of the best quality (containing 0·292 per cent. of lead) had been used, the silver coin would have contained 0·158 per cent. of lead; if the second quality (containing 0·494 per cent. of lead) has been employed, the coin may contain 0·268 per cent. of lead. Between these two limits, all our determinations of lead in American silver will be found to lie.

In offering this explanation of the occurrence of lead in American silver coin, we would by no means affirm that the zinc is the exclusive source of this impurity, for it is not at all improbable that a portion of the lead is derived from the leaden vats in which the reduction of the chloride of silver is effected, or from the sulphuric acid which is used to excite the reaction.

Protection of Iron and Steel.

Prof. Vogel Junior recommends, for the protection of iron and steel tools against rust, a solution of white wax in benzine. Moderately heated benzine dissolves half its weight of wax; and if this solution be carefully applied to the tool with a brush, the evaporation leaves a very adhesive and permanent coating of wax, which will preserve the metal even from the action of acid vapors.—*Dingler's Polytechnisches Blatt.—Bulletin de la Société d'Encouragement pour l'Industrie Nationale.*

On a new Method of Producing on Glass, Photographs or other Pictures, in Enamel Colors. By F. JOUBERT.

From the Journal of the Society of Arts, No. 444.

(Continued from page 179.)

Discussion.—Mr. Harvey inquired whether the method now employed for coloring daguerreotypes was applicable to the process just described, provided the colors used were such as to stand the firing.

M. Joubert replied in the affirmative—mineral colors being used

* Brightly's Dig. Laws U. S., for Standard, Title *Coinage*, s. 3; for Weights, Title *Coinage*, s. 13.

† See our Memoir in Mem. Amer. Acad. [N. S.], viii. 61, Table I.

instead of vegetable colors, as in the case of photographic coloring. The difference between the two was this:—Where they applied the color to a photograph, or drawing upon paper, the color remained as applied; but any one acquainted with glass painting knew that various colors were acted upon differently under the action of heat in the firing. For yellow color they used a preparation of silver and copper, and minerals were used more or less in the preparation of all the colors for burning in. If the colors were applied by the brush, as in the coloring of daguerreotypes, the process amounted, in fact, to that of glass painting, properly speaking, instead of its being a mechanical process as this professed to be. His (M. Joubert's) object had been to bring this invention to a purely mechanical result, so as to obviate the necessity of employing artists for glass painting. The object of the invention was to reproduce photographs or designs in a perfect form by mechanical manipulation.

Mr. Philip Palmer would express his obligations to M. Joubert for having brought forward this subject of window glass. Important as the subject was, within the last few years it had seldom been brought before the attention of this Society. It was now thirty years since he became a member of the Society, and he recollected that, at the first meeting he attended, the subject was that of window glass, and he believed the same subject had only been brought before them two or three times since. The Great Exhibition of 1851 afforded an opportunity for bringing this subject forward, and the approaching Exhibition of 1862 would, he hoped, probably furnish another occasion for doing so. With regard to the antiquity of glass, he might mention that in the British Museum there was a specimen of glass said to be of a date 3000 years before Christ. Whether that was the fact or not he did not know, but it was certain that some very old specimens of glass were to be seen in the British Museum. He quite agreed with the remark in the paper, that glass was so cheap and common that they were apt to lose sight of its immensely diversified qualities, and, therefore, any attempt to ornament it in this beautiful and artistic manner, deserved the strongest encouragement of all lovers of art. There was a period in the history of the importation of painted glass which was personally interesting to himself, and which was spoken of by Horace Walpole. It was matter of history, but was connected with his (Mr. Palmer's) great-grandfather, who imported large quantities of painted glass in 1753–4, and the circumstance gave rise to an amusing chapter in Walpole's letters. With regard to the cost of glass painting, he did not know that that was a subject which he ought to touch upon in the presence of several eminent glass painters whom he saw in the room, but he might venture to make this general remark —that a really good work of art must be well paid for; and if they employed first-rate talent, whether in painting upon glass or in architecture, that talent must be paid for; and glass painters were quite as much artists as those who painted upon canvass or paper. With regard to the decoration of glass at a moderate expense for the purpose of shutting out the view of dead walls, or a disagreeable neigh-

bor, M. Joubert had contrasted this process with the use of plain ground glass. That had been used for a great many years; enamel patterns had been produced in such immense quantities that the use of the latter had been much larger than that of plain ground glass. The patterns had become so common that architects were always seeking for something new. This process, as it appeared to him, was calculated to supply that want, inasmuch as it enabled persons to select any number of subjects and have them reproduced. Having been connected, as he and his family had been, for a century and a half with the glass trade, he wished to express his acknowledgments to M. Joubert for having brought this subject before them; and he would add, that he was quite sure all who were interested in the trade would be happy to give him the support which his ingenuity deserved, and to assist in bringing before the public this very beautiful invention.

Mr. Peter Graham would ask one or two questions of a practical nature. First, what was the largest surface to which this process had yet been applied, and whether there was any limit to the surface, and how many colors could be used in one picture. Also, whether there was any difficulty in employing a number of colors in combination, so as to produce a highly artistic effect; and, further, to what extent photographs could be enlarged or diminished, to bring them to such a size as might be required. He thought the invention might be applied to decorative purposes with good effect. He would also inquire what was the cost of these specimens, as compared with paintings upon glass of the same size, and whether many failures were experienced in the attempts to produce these pictures?

M. Joubert replied, with regard to the size, that the specimens he had exhibited, as being unburnt, $24 \times 17\frac{1}{2}$ inches, were the largest he had yet produced, but he apprehended the size was only limited by the dimensions of the kiln. There would, of course, be a little more care required in manipulating upon a large picture, but there would be no difficulty in producing a picture of three or four feet square. The only difference was the greater risk in burning it; the larger the surface of glass to be subjected to any manipulation or firing, the more the risk was increased. As to the combination of colors, if he understood the question aright, it was what combination of colors could be burnt at the same time. That was a question which he was scarcely in a position to answer with certainty at present. In the specimens upon the table, it would be observed that they were almost all of one color. He thought it better to produce them perfectly in monochrome in the first instance, and having mastered the difficulties of manipulation in one color, then to go to three or four colors. He would call attention to one specimen, having a colored border with an edging which had the appearance of ground glass. It was, however, produced by a coating of flux. The colored border was also added, and was burnt in at the same time with the white enamel—all in one firing—showing that a color and white enamel could be accomplished at the same time. He had been able to produce four colors in one burning. He had no doubt, with improved manipulation, a variety of

colors could be produced at one firing; but all glass painters were aware that to attempt to produce perfect copies of pictures, with all shades of colors, would be to branch into another line of art. Instead of being mere printing, it would become regular glass painting. It had been his object to avoid that from the first. Glass painting was executed very beautifully in this country, and upon that subject he might remark that an art which flourished 200 years ago seemed to have fallen into disuse for the last 100 years, and it was only at the beginning of the present century that glass painting had seemed to have revived. Although glass painting was not invented in England, he might say that this was the country in which that art had been kept alive more than in any other. The third question asked by Mr. Graham, was with respect to the size to which pictures could be enlarged or diminished. The camera was the instrument employed both for enlarging and reducing. The enlarging of designs through the camera was practised in Paris more extensively than in this country. In a short time there would be an exhibition here, in which objects would be shown as large as life. This process was in operation at present in Paris, but a large apparatus was now being prepared for introducing it into this country. They were aware that any photograph or drawing enlarged beyond a certain point was not pleasant to look at; and in proportion as a large picture diminished, it acquired finish; while, on the other hand, enlargement beyond a certain degree exaggerated the defects of the picture. With regard to the cost of these specimens as compared with ordinary glass painting, it was difficult to give an answer to that question, because there was no fixed price for glass painting with which it could be compared. The operations of the glass painter were exposed to many accidents. A work which had occupied many weeks or months, might spoil in the last firing; therefore the risk, being so considerable, was one reason why the price of glass painting must be arbitrary. Taking the average of the smaller specimens exhibited, he believed they could be sold at about 8*s*. per sqnare foot. It was found necessary to fix the price according to measurement. If an architect had 100 square feet to cover, he must be able to estimate the cost without entering into the question of subject. He (M. Joubert) had no doubt when this invention was taken up generally by the manufacturers, the cost would be very considerably reduced. With regard to the failures he had met with, if he mentioned the number of failures he experienced at the beginning he should do a wrong thing, because in the early stage of an invention failures were frequent. Comparing the failures of the last three months with those that occurred two years ago, he might state that they were now only 1 per cent., whilst formerly they were as much probably as 50 per cent.

Mr. Phillips understood M. Joubert to state that this process could be applied to ceramic bodies. He begged to inquire whether it was equally applicable to china as to glass, and in that case, could it be applied to any description of form, as well as to a flat surface?

M. Joubert replied that, in the specification of his patent, he had

included ceramic substances as being part of the invention. He had already shown, to a few friends, some successful specimens of the application of this process to china; but he found that one branch of the subject at a time was quite enough to occupy his attention. He had chosen between the two, and had worked upon glass in preference; but that being now, as he considered, brought into good working order, his intention was to apply himself now to developing the invention with respect to china, because he was not only convinced that it would answer, but that it was possible to apply it to curved as well as to flat surfaces.

Mr. Gee inquired whether these subjects were liable to injury from external exposure to the weather or from the ordinary rubbing in the operation of cleaning glass?

M. Joubert replied, that the picture, forming an integral portion of the glass itself, could not be injured from the causes mentioned.

Mr. Gee, with reference to the applicability of the process to convex surfaces, inquired whether the subjects were not liable to distortion?

M. Joubert, in answer to that, would state, that an eminent photographer was about to introduce a method of printing photographs upon curved surfaces. He had seen some of those impressions which left no doubt upon his mind that his process would be applicable to all forms of glass or china. The subjects would not be distorted.

Mr. Bishop remarked, that when he was at Pompeii, about two years since, he was shown a piece of plate glass about three-sixteenths of an inch in thickness, which was the earliest specimen of plate glass he had met with.

M. Joubert was aware of the fact just mentioned, but there seemed to be some difficulty in establishing the fact that it was really glass. Some learned persons considered it was not glass, but merely a piece of transparent slate or mica that was used in ancient times, which, through the agency of fire, when those cities were invaded by lava, had assumed the appearance of glass. It was a great question whether it was glass.

Mr. Bishop said that that might have been the case as regarded Herculaneum, which was covered with melted lava, but in the case of Pompeii it was covered with wet cinders and mud, and therefore no vitrification could have taken place. The specimen to which he alluded, was about one foot by nine inches; he had carefully examined it, and should pronounce it to be glass, resembling as nearly as possible the material of the present day known as cast plate glass.

M. Joubert had not seen the specimen alluded to by Mr. Bishop, and could, therefore, give no decided opinion upon it; he could only judge from the reports he had heard from other persons. A distinguished glass manufacturer (Mr. Chance) read a paper before this Society some years ago, in which he stated that glass had been found in the ruins of Pompeii. Upon reading that, he (M. Joubert) was somewhat startled at the assertion, because he was intimately acquainted with persons who had traveled there, and who had made this sub-

ject matter of special investigation, but they had told him it was very doubtful whether it was glass at all. He should not like to decide against the opinion of a gentleman who had seen the thing itself, as his opinion was founded entirely upon the statement of others.

Mr. B. Waterhouse Hawkins said as M. Joubert had submitted to his catechism with so much patience, he begged to trouble him with one more question. As he had included ceramic manufactures in the category of materials susceptible of receiving the benefit of this wonderful invention, he (Mr. Hawkins) would ask whether he had taken into his consideration the possibility of applying this beautiful process to the cheap decoration of ceramic ware, porcelain, and ordinary pottery, so that they might ultimately hope for the banishment of the "willow pattern," and the substitution of varied and more artistic patterns produced by photography, and whether there was a probability of their being so cheaply produced as that they could be multiplied in the same manner, and nearly as cheaply as the present mode of printing upon biscuit.

M. Joubert would be glad if he could candidly say that he even saw, looming in the distance, a prospect of applying this process to the displacement of the old willow pattern upon our crockery, but at present he did not think there was much prospect of this, and for this reason:—these pictures were all printed photographically, and every one knew that the process was not very rapid, the operation being liable to be more or less influenced by the state of the weather; but he was quite confident that some day or other the present mode of printing, which was applied to photography generally, would be superseded by the discovery of a mode of producing a perfect metal plate, engraved by means of photography itself. When that was accomplished, no doubt one of its first practical applications would be to the patterns of pottery wares, and they might then have a chance of bidding adieu to the willow pattern for ever.

Mr. Wm. Hawes did not rise for the purpose of putting more questions to M. Joubert, but if he were inclined to make an observation upon the very able paper they had heard, and the discussion which had followed upon it, it would be to express the great satisfaction they must all have felt at the manner in which the various inquiries had been replied to by M. Joubert. They must have arrived at the conclusion, from what they had heard, that here was a new application of one of the newest and most recent discoveries connected with the art and industry of the present day. Photography, a young art, was applied in a new form, and with great facility, to produce most beautiful effects; and they had been told with a degree of fairness and candor which made them feel satisfied that every word was true, that, in the experience of only two years, so great a proficiency had been attained, that, whereas the failures were formerly fifty per cent., they were now reduced to not more than one per cent. They had also been told, incidentally in the discussion, that the art of painting upon glass had fallen into neglect for a considerable period in this country, but had again progressed within the last few years. It was

about 120 or 130 years ago that the excise was put upon glass. The effect of that interference was to check the application of glass to the most beautiful purposes of domestic life. About 100 years ago, the art of painting on glass relapsed, and had only recently revived. It was singular that that should be just about the time when the excise was put upon glass. If that fact was incorrect, his reasoning would fail; but he deduced this conclusion from it—that this was another instance that where there was entire freedom of a manufacture from fiscal imposts, men like M. Joubert could study and experimentalize at comparatively little cost, whereas, if the law put a high duty upon this material, the cost alone would almost have prevented the advancement of such an invention as this. No one could doubt that if M. Joubert could produce designs of this kind, at a cost of 8*s*. per foot, in the present stage of the invention, in a few years time they would be produced at a price which would bring them into common use. It only wanted more practice, more experience, and manufacture on a larger scale, to reduce the present price of 8*s*. to almost a nominal sum. The photograph itself was almost costless; the skill was in the transferring of it. This beautiful invention, he had no doubt, would in a short time become an important element in the ornamentation of their houses. With regard to the probability of this invention ever superseding the willow pattern, he believed, in point of economy, that would hardly be achieved, because the printing such designs as the willow pattern was the cheapest process that could be conceived or introduced. As a member of the Council he begged to express his thanks to M. Joubert for bringing a subject of this kind so ably before them. Generally speaking, he had a strong objection to patentees making use of this Society as a means of disseminating their own views with regard to their own patents. But this was an extraordinary case. Here was not only a patent brought before them, but a beautiful and novel application of art, and it was the duty of this Society, whose main object was to encourage the arts, to give an opportunity of bringing it thus before the public, especially when it was brought forward with such candor as had been shown on the present occasion.

Mr. Philip Palmer apologized for his interruption of Mr. Hawes' remarks, with which he agreed, except as to the excise duty upon glass having stopped the art of painting upon glass. M. Joubert had not hinted at such a thing, and he was afraid his friend Mr. Hawes had adopted the popular opinion as to the effect of the repeal of the duty on glass. If the repeal of that duty had done anything, it had had the effect of making the manufacture of glass a monopoly instead of an open trade. At the time the duty on glass was repealed, there were twenty manufacturers; at the present time there were only six. A much larger quantity of glass was produced, but six houses were sufficient to manufacture what was formerly produced by twenty. The question of the value of glass, in his opinion, had very little to do with the cost of producing these pictures. A piece of glass which now cost sixpence or ninepence, was not worth more than double that

sum when the duty was in existence; so that, previous to 1845, M. Joubert could have produced his designs at the same cost plus the extra price of the glass at that time compared with the present. He could not consider that the imposition of an excise duty upon glass had had the effect of checking the art of painting on glass, but he rather attributed the disuse spoken of to the want of taste of the period. They knew in what a low state the arts were in this country a century ago, and it was only right to say that this Society was one of the means of keeping alive a taste for art.

M. Joubert, in mentioning the average price of 8*s.* per square foot, wished it to be understood that the remark applied to the smaller specimens on the table. With reference to what had fallen from Mr. Hawes upon the subject of the duty upon glass, he (M. Joubert) would say that he so far concurred in what that gentleman had said, that if glass had been as expensive now as it was before the repeal of the duty, he did not think he should have ventured to engage in this process at all.

Mr. Hawes further remarked that this was not the place to enter upon an argument as to the effects of the repeal of the duty upon glass. There might have been twenty manufacturers before the repeal, and there might be only six now; but if the six could now do that which the twenty did before, the public were no losers by that circumstance. To adopt Mr. Palmer's reasoning was to go back twenty or thirty years in their commercial policy. They had before them the fact just stated by M. Joubert, that if the experiments which had led to the perfection of this process had had to be performed upon an article bearing a high excise duty, the cost of the experiments would have been such as to have deterred him from undertaking them.

The Chairman said the agreeable duty now devolved upon him of expressing, not only his own views, but he believed the views of the meeting at large, upon the beautiful and novel invention which had been brought before their notice that evening. They sometimes saw decorations of windows which, though beautiful within, had a very unsightly appearance from the outside; but here they had both sides equally beautiful. It was an invention of a peculiar kind. It was pure photography applied to glass, with this addition, that it was burnt into the substance of the glass, and became as durable and indestructible as the glass itself; and this he apprehended constituted one of the chief merits of the invention. It would enable them, he trusted, before long, to obtain copies of beautiful pictures for decorative purposes, at comparatively small cost. They would not have to form the designs themselves, or to employ expensive artists to execute them; but, by the aid of the photographer, they might have reproductions of the works of Raphael, or even actual scenes from nature. There was one specimen in particular to which he would call their attention. It was a scene of some Frenchmen reading a proclamation in Paris during the late Italian war. In this way, portraits of friends might be employed in the ornamentation of their dwellings. It was the combination of the two great arts of photography and enameling. It had

this superiority over paper photographs; a strong suspicion prevailed that photographs would not last for ever, that the effects produced by the action of light might be destroyed by the light; but by this process the impression was rendered as durable as the glass itself. He was sure the feeling of the meeting would be with him when he expressed the gratification which this novel and interesting application of the photographic art had afforded them. He entertained the highest sense of the value of this paper; but what enhanced its value, were the answers given by M. Joubert to the many inquiries which had been put to him. He did not over-answer the questions, but when he dealt with matters which were more subjects of surmise than of actual experience, he replied with a modesty and talent which carried with it, to his (the Chairman's) mind, a perfect conviction of his sincerity, as well as of his practical ability.

The vote of thanks having been passed,

M. Joubert returned thanks for the kind manner in which his paper had been received. He could not allow this meeting to separate without conveying to every person present, as far as he was able to do so, his extreme feeling of gratification for the manner in which he had been received as a stranger in this country, and especially in this Society, since he had had the honor of being a member of it. If bringing this invention before them, which had cost him some labor and anxiety to perfect, had been the means of ministering to their gratification and enjoyment, he felt he was only attempting to repay the debt of gratitude which he owed to the people of this country.

A Substitute for Silver.

From the Lond. Mechanics' Magazine, June, 1861.

Messrs. De Ruolz and De Fontenay have lately obtained, after several years experiments, a new alloy, which may be very useful for small coin and for many industrial uses. It is composed of one-third silver, 25 to 30 per cent. of nickel, and from 37 to 52 per cent. of copper. Its inventors propose to call it *tiers-argent*, or tri-silver. Its preparation is said to be a triumph of metallurgical science. The three metals, when simply melted together, form a compound which is not homogeneous; and to make the compound perfect, its inventors have been compelled to use phosphorus and certain dissolvents which they have not yet specified. The alloy thus obtained, is at first very brittle; it cannot be hammered or drawn, and lacks those properties which are essential in malleable metals. But after the phosphorus is eliminated, the alloy perfectly resembles a simple metal, and possesses in a very high degree the qualities to which the precious metals own their superiority. In color it resembles platinum, and is susceptible of a very high polish. It possesses extreme hardness and tenacity. It is ductile, malleable, very easily fused, emits when struck a beautiful sound, is not affected by exposure to the atmosphere, or to any but the most powerful reagents. It is without odor. Its specific gra-

vity is a little less than that of silver. An alloy possessing these properties must be very useful to gold and silver smiths. It can be supplied at a price 40 per cent. less than silver, and its greater hardness will give it a marked superiority. It may also serve as a substitute for gold-plated or silver-plated articles, which are now so common on account of their cheapness, but which will not bear re-plating more than a few times, and which are, in the long run, sometimes more expensive than the pure metal. The new alloy, however, will be most useful for small coin. Its preparation and coining are so difficult that the coin made of it cannot easily be counterfeited. Its hardness would render it more durable than silver; and thus the expense of re-coining, and the heavy loss arising from the wearing of our silver coinage, would be greatly diminished.

Liquid Diffusion applied to Analysis. By Thomas Graham, Esq., F. R. S., Master of the Mint.

[From the Proceedings of the Royal Society, No. 44.]

The unequal diffusibility of different substances in water appears to present means of separation not unlike those long derived from unequal volatility. For as regards diffusion, there exists a "volatile" and also a "fixed" class of substances; and these distinctions appear to correspond with differences in molecular constitution of a fundamental nature. Much value is attached to diffusion, as affording the means of bringing out clearly, and subjecting to numerical expression, the distinctive properties of what appear to be two great divisions of chemical substances.

The first, or *diffusive*, class of substances, are marked by their tendency to crystallize, either alone or in combination with water.

When in a state of solution, they are held by the solvent with a certain force, so as to effect the volatility of water by their presence. The solution is generally free from viscosity, and is always sapid. Their reactions are energetic and quickly effected. This is the class of *crystalloids*.

The other class, of low diffusibility, may be named *colloids*, as they appear to be typified by animal gelatine. They have little if any tendency to crystallize, and they affect a vitreous structure. The planes of the crystal with its hardness and brittleness, are replaced in the colloid by rounded outlines with more or less softness and toughness of texture. Water of crystallization is represented by water of gelatination. Colloids are held in solution by a feeble power, and have little effect on the volatility of the solvent. They are also precipitated from their solution by the addition of crystalloids. The solution of colloids has always a certain degree of viscosity or gumminess when concentrated. They appear to be insipid or wholly tasteless, unless when they undergo decomposition upon the palate, and give rise to sapid crystalloids. Their solid hydrates are gelatinous bodies. They are united to water with a force of low intensity; and such is

the character of the combinations in general between a colloid and a crystalloid, even although the latter may be a powerful reagent in its own class, such as an acid or an alkali. In their chemical reactions, the crystalloidal appears the energetic form, and the colloidal the inert form of matter. The combining equivalent of the colloid appears always to be high, and it has a heavy molecule. Among the colloids rank hydrated silicic acid, and a number of soluble hydrated metallic peroxides, of which little has hitherto been known; also starch, the vegetable gums and dextrin, caramel, tannin, albumen, and vegetable and animal extractive matters. The peculiar structure and chemical indifference of colloids appear to adapt them for the animal organization, of which they become the plastic elements.

Although the two classes are widely separated in their properties, a complete parallelism appears to hold between them. Their existence in nature appears to call for a corresponding division of chemistry into a crystalloid and a colloid department.

Although chemically inert in the ordinary sense, colloids possess a comparative activity of their own, arising out of their physical properties. While the rigidity of the crystalline structure shuts out external impressions, the softness of the gelatinous colloid partakes of fluidity, and enables the colloid to become a medium for liquid diffusion, like water itself. The same penetrability appears to take the form of a capacity for cementation in such colloids as can exist at a high temperature. Hence a wide sensibility on the part of colloids to external agents. Another eminently characteristic quality of colloids, is their mutability. Their existence is a continued metastasis. A colloid may be compared in this respect to water while existing liquid at a temperature below its usual freezing point, or to a supersaturated saline solution. The solution of hydrated silicic acid, for instance, is easily obtained in a state of purity, but cannot be preserved. It may remain fluid for days or weeks in a sealed tube, but is sure to gelatinize at last. Nor does the change of this colloid appear to stop at that point. For the mineral forms of silicic acid, deposited from water, such as flint, are found to have passed, during the geological ages of their existence, from the vitreous or colloidal into the crystalline condition (H. Rose). The colloidal is in fact a dynamical state of matter; the crystalloidal being the statical condition. The colloid possesses ENERGIA. It may be looked upon as the probable primary source of the force appearing in the phenomena of vitality, as living matter without form. To the gradual manner also in which colloidal changes take place (for they always demand time as an element), may the chronic nature and periodicity of vital phenomena be ultimately referred.

For the separation of unequally diffusive crystalloids from each other, jar-diffusion was had recourse to. The mixed solution was conveyed by means of a pipette to the bottom of a column of water contained in a cylindrical glass jar. A kind of cohobation takes place, a portion of the most diffusive substance rising and separating from the less diffusive substances, more and more completely, as it ascends.

The separation of a crystalloid from a colloid is more properly effected by a combination of diffusion with the action of a septum composed of an insoluble colloidal material. Animal membrane will serve for the latter purpose, or a film of gelatinous starch, hydrated gelatin itself, albumen, or animal mucus. But by much the most effective septum used was paper, as it is metamorphosed by sulphuric acid (Gaine). It is now supplied by Messrs. De la Rue, and has become familiar under the name of "vegetable parchment" or "parchment-paper." From sheet gutta-percha a flat hoop is formed, eight or ten inches in diameter by three inches in depth, and one side is covered by a disc of parchment-paper, so as to form a vessel like a sieve. A mixed solution, which may be supposed to contain sugar and gum, is placed upon the septum to a depth of half an inch, and the instrument then floated upon a considerable volume of water contained in a basin. Three-fourths of the sugar diffuses out in twenty-four hours, and so free from gum as to be scarcely affected by subacetate of lead, and to crystallize on the evaporation of the external water by the heat of a water-bath.

The unequal action of the septum, which causes the separation described, appears to depend upon this: The crystalloid sugar is capable of taking water from the hydrated colloidal septum, and thus obtains a medium for diffusion; but the colloid gum has little or no power to separate the combined water of the same septum, and does not therefore open the door for its escape by diffusion, as the sugar does. This separating action of the colloidal septum is spoken of as *dialysis*.

Dialysis was applied to the preparation of various colloids. The mixed solution obtained by pouring silicate of soda into water acidulated with hydrochloric acid, was placed upon a parchment-paper dialyser and allowed to diffuse into water, the latter being occasionally changed. After the lapse of five days seven-eighths of the original silicic acid was found to remain liquid upon the septum, and to be so free from hydrochloric acid and chloride of sodium as not to give a precipitate with acid nitrate of silver. The true hydrated alumina, and also Mr. Crum's metalumina, were obtained soluble by dialysing solutions of these oxides in the chloride and acetate of the same metal. So also the hydrated peroxide of iron, in addition to the hydrated metaperoxide of iron of M. Péan Saint Gilles, and the soluble hydrated chromic oxide. The varieties of prussian blue are obtained soluble by dialysing their solution in oxalate of ammonia, the latter salt diffusing away. Stannic and titanic acids appear as insoluble gelatinous hydrates.

A solution of gum-arabic (gummate of lime), dialysed after an addition of hydrochloric acid, gave at once the pure gummic acid of Frémy. Soluble albumen is obtained in a state of purity by dialysing that substance with an addition of acetic acid.

Caramel of sugar, purified by repeated precipitation by alcohol and afterwards by dialysis, contains more carbon than any of the caramelic bodies of Gélis; it forms a tremulous jelly when concentrated, and appears decidedly colloidal. Caramel, like other colloids, has a

soluble and an insoluble modification. The latter has its solubility restored by the action of alkali, followed by that of acetic acid and subsequent dialysis.

Dialysis proves highly useful in separating arsenious acid and metallic poisons from organic fluids. Defibrinated blood, milk, and other organic fluids charged with a few milligrammes of arsenious acid, and placed upon the dialyser, were found to impart the greater proportion of the arsenious acid to the external water in the course of twenty-four hours. The diffusate was so free from organic matter, that the metal could be readily precipitated by sulphuretted hydrogen, and the quantity weighed.

Ice at or near its melting-point appears to be a colloidal substance, and exhibits a resemblance to a firm jelly in elasticity, the tendency to rend, and to reintegrate on contact.

The consideration of the properties of gelatinous colloids appears to show that osmose is principally an affair of the dehydration of the gelatinous septum under influences having a catalytic character, and that the phenomenon is independent of diffusion. The colloidal septum is capable of hydrating itself to a higher degree in contact with pure water than in contact with alkaline solution. Colloidal septa, swollen in consequence of contact with dilute acid or alkali, appear to acquire increased sensibility to osmose, in consequence of their unusually high degree of hydration.

Steam Engine and Boiler Experiments at the Scotland Street Iron Works, Glasgow. By Mr. William Tait.

[Read at the Institution of Engineers of Scotland.]

From the Lond. Mechanics' Mag., January, 1861.

Three years ago, the writer commenced a series of experiments for the purpose of verifying in some measure the advantages alleged to be derived from the use of high-pressed steam, worked more or less expansively, as compared with steam of a lower pressure, worked in the usual way. Those experiments, however, were soon abandoned, because the engine was very often worked late, and occasionally all night, with a load at night probably not more than one-half of that which constituted the day's work. It was also found inconvenient to attend at night to take pressure diagrams. Similar experiments were again instituted a few months ago, and although not so complete as were originally intended, they may yet be interesting to those occupied with similar pursuits. The economic conditions under which a given weight of coal is made to perform a given amount of work, form an important object of inquiry.

The experiments were commenced with steam at a pressure on the safety valve of 55 lbs. per square inch, cutting off the steam in the cylinder at one-sixth of the stroke. These experiments were meant to be continued from week to week, and on each succeeding week with four inches more steam in the cylinder, until three-fourths of the stroke was arrived at; but this intention was departed from in consequence

of the very irregular and often excessive quantity of coal required to keep up the steam. This irregularity arose from the circumstance of the boiler top being wholly unprotected from the weather, in consequence of which, when winter came, with rain and snow, the consumption of coal was increased from 25 to 30 per cent. over the usual average quantity. The experiments were therefore discontinued for a few days until the boiler and steam-pipes were covered—the boiler with hair-felt and bricks, and the pipes with felt, saw-dust, and wood.

On Monday, 12th December, 1859, the experiments were resumed with the expansion valve set to cut off the steam at one-fifth of the stroke, and were continued until Saturday, 31st December—three weeks; and from Monday, 9th, until Saturday, 14th January, 1860, being four weeks in all, or 240 hours. Diagrams were taken several times a-day, and the mean accepted as showing the actual quantity and force of the steam in the cylinder. M'Naught's indicator was used, and its accuracy was occasionally tested both on the boiler and valve casing alongside of Bourdon's pressure gauges, the one in fact checking the accuracy of the other. The coal was accurately weighed, and the quantities recorded represent every pound that was consumed, including the getting up of the steam in the mornings, gathering the fire at night, and on Sundays. The ashes and clinkers were also carefully weighed.

The evaporation was tested by measuring accurately the surface area of the water in the boiler, and noting its height on the gauge glass before starting the engine at 10 o'clock, A. M., and at 2 o'clock, P. M., and stopping again at 12 o'clock, and at 5 o'clock, P. M., until respectively the fall of the water was ascertained. The engine was stopped for the purpose of letting the water be as quiescent as possible. This again was partially checked by noting the quantity of water taken from a cistern.

The boiler is 32 feet 6 inches long, by 5 feet 2 inches in inside diameter, with two flues passing through it longitudinally, each 18 inches in inside diameter. The fire-grate measures 4 feet by 3 feet 3 inches, and the ash-pit is fitted with doors. On the centre of each door is a fan valve for regulating the admission of air. The wall at the side of the grate nearest the chimney is built close up to the boiler. There are air-holes in this wall, the air being supplied by a valve in front of the building. This air is of course to aid in abating the smoke nuisance. The furnace bridge rises to within five inches of the boiler, allowing about 510 square inches for the passage of the gases, or about 40 inches per foot of fire-grate. There is no part of the outer shell of the boiler exposed to the action of the fire excepting the part above the furnace, and onwards to where the flame turns upwards to the flue tubes. The recipient surfaces computed by the usual method are equivalent to about 23 H. P. Between the boiler and damper there is another bridge, which rises to a level with the centre of the tubes, the opening over it being about 300 square inches. The gases, after passing this bridge, descend and pass beneath the damper into the chimney. The steam-pipe to the engine is 49 feet long by 5 inches in

diameter, and is carried through the chimney at a certain point, where it is divided into four pipes made of copper, and joined to the iron pipe in the brick-work of the chimney. These pipes possess in all about 26 feet of surface, and may take up a little, a very little of the heat manifestly going to waste up the chimney.

The engine is high-pressure, with cylinder 20 inches in diameter, and a stroke of 4 feet, and it made with great regularity 34 strokes per minute—this at any rate being the mean velocity. The cylinder in not jacketed, and has no covering of any kind. The slide-valves are worked by eccentrics both for steam and expansion. Figs. 1 and 2 represent two pairs of top and bottom diagrams taken from the cylinder.

The following are the data and mean results of four weeks observations:—

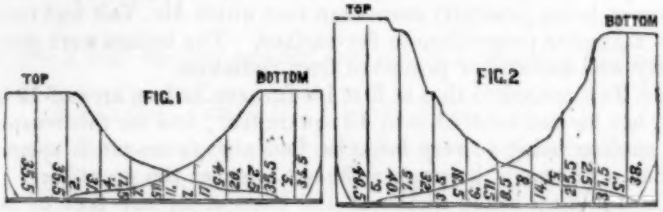
Length of boiler,	32 ft. 6 ins.
Diameter of do. (internal),	5 ft. 2 ins.
Number of flues,	Two.
Diameter of do. (internal),	1 ft. 6 ins.
Area of under surface of boiler exposed to the fire,	61 ft.
Do. end of boiler exposed,	8 ft.
De. flues,	306 ft.
Heating surface per indicated H. P.,	10 ft. 7 ins.
Quantity of water in boiler (6 ins. above flues),	351 cub. ft.
Do. do. per H. P.,	10·028 cub. ft.
Steam space in boiler,	208 cub. ft.
Do. per H. P.,	5·94 cub. ft.
Area of fire-grate,	13 sq. ft.
Do. do. per H. P.,	53·5 sq. in.
Water evaporated per hour,	25 8 cub. ft.
Do. do. per H. P. per hour,	·73 cub. ft.
Time of working,	240 hours.
Coals consumed,	68,544 lbs.
Do. per hour,	285·6 "
Do. per H. P. per hour,	8·08 "
Pounds of water evaporated per pound of coal,	5·65 "
Clinkers and ashes,	3509 "
Per centage of do. to the coals consumed,	5·1 per cent.
Thickness of fire-bars,	1 inch.
Spaces between do.,	⅝-inch.
Description of coal used,	Wishaw dross.
Heat of feed-water,	124° Fahr.
Pressure of steam in boiler,	40 lbs.
Do. in valve-casing,	40 "
Initial pressure on piston,	35 "
Average do. do.,	13·65 lbs.
Travel of piston before steam is cut off, nearly	10 ins.
Indicated H. P. (usual method), viz: area of cylinder × by effective pressure × by feet traveled per minute, / 33·000,	35·33
Length of steam-pipe,	49 ft.
Diameter of do.,	5 in.
Method of superheating. By 4 copper pipes through chimney 3⅛ in external diameter—length 28 ft.—heating surface,	26·4 ft.
Temperature of steam in boiler at 44 lbs.,	292° Fahr.
Do. do. in valve-casing at 44 lbs.,	291° "

The temperature of the steam in the boiler and valve-casing was tried, for the purpose of ascertaining whether any and to what extent

heat was imparted to the steam by the copper pipes in the chimney. In the valve-casing the temperature was 1° lower than in the boiler; the one was 2° and the other was 3° below what was due to the pressure. This discrepancy was no doubt owing to currents of cold air, and, at the valve-casing particularly, to the radiation of heat from the surface of the part where the thermometer was applied. At times, however, the temperatures were uniform and correct.

The pressure in the boiler and in the casing was indicated by Bourdon's gauges, and showed a nearly absolute uniformity—the greatest variation being from 1 lb. to 1½ lbs.; the excess being sometimes in the boiler and sometimes in the casing.

Regarding the quantity of coals consumed, it must be noted that the weather was nearly constantly wet during the experiments; the coals were brought in daily as required, and were weighed often when saturated with water; this water forming, in some instances, a large per centage. The weather also had an adverse effect on the boiler. The stock of coal in the work was kept small, to prevent the temptation to any excess in firing.



Mean H. P. 37·09.

Mean H. P. 37·265.

The steam-space in the boiler is noted, because it is large in proportion to the quantity of steam used at a single stroke of the engine; this quantity, including the filling of the steam-port, was about 2½ cubic feet, which was just about one eighty-third part of the steam in the boiler. This circumstance prevented in a great measure the liability of the water to pass off with the steam—water passing off in that way accounting satisfactorily for the apparently very great success attending many experiments on record; the success being in direct proportion to the amount of priming, or water carried off with the steam. It is doubtful whether or not any material benefit was derived from so partial an attempt at superheating as was tried in the present experiments.

The heat in the flue was high, and, on several occasions, melted zinc; in fact, it was melted on every repetition of the experiment if allowed to remain long enough in the flue. Five pounds of iron, after being hung in the flue for some hours, gave 6° of heat to a cubic foot of water, and copper gave the same result, whilst five pounds of firebrick gave 8°. It would thus appear that the gases entered the chimney at a temperature of about 720° Fahrenheit. A close approximation to the temperature of the gases in a flue is obtainable by suspending a piece of iron in it until saturated with the heat, and then immersing it in six times its weight of water. The number of degrees of

temperature acquired by the water multiplied by 60 gives the temperature of the gases.

The writer has to express his regret that the intention with which he commenced these experiments has not been more fully carried out. Although he foresaw difficulty in arriving at strictly true comparative results, in consequence of the power of the engine being so much in excess of the work it had to perform, and of the continual variation in the quantity of that work, the difficulty has proved much greater than he ever anticipated, even without the subject of the comparative results to be obtained by different degrees of expansion having been entered on.

—

In a discussion which followed the reading of the preceding paper, Mr. Davison, from New York, said the boiler was of a form very common for high-pressure engines in America. Generally the fire was so placed as to allow the heat to pass first under the boiler and then through the flues, instead of passing first through the flues as in this country. That plan was adopted for safety and economy in fuel, the economy being generally more than that which Mr. Tait had recorded, with a greater proportionate fire-surface. The boilers were generally pretty well covered or protected from radiation.

Mr. Tait remarked that at first his furnace had an area of 19 square feet, but he had reduced it to 13 square feet; and for this reason, that the surface being so very large he had always too much steam when he had a fire upon the grate sufficient to cover the grate-bars.

Dr. Rankine asked what was the ratio of square feet of heating surface of the boiler to pounds of coal consumed per hour.

Mr. Tait answered that it was 285 lbs. of coal to a heating surface of 375 feet, or about 4 feet of surface to 3 lbs. of coal.

In answer to other questions as to whether the air-spaces in the furnace wall were not too small, and as to the heat of the water let into the boilers, Mr. Tait said that so far from that being the case, the damper of the furnace, which was 22 inches wide, had never to be raised above five inches. In fact, he could consume any reasonable quantity of coal in it. The draft was far too great for the size of the furnace. They had been feeding the boiler with water at 140°; but he expected that they would soon feed it with water at 180°.

Mr. Brownlee expressed his wonder that condensing engine-boilers should even be fed with water at less than 200°, it being so easy to have it heated even above that point.

Dr. Rankine said, that in high-pressure engines it seems to have answered well to condense the steam at 200° or thereabouts, and to feed in water to the boilers at 200°, or a little higher, and thus save the fuel. He believed that was done in Mr. Beattie's locomotives, and was found to save fuel considerably.

Mr. D. More said he had been much pleased with an inspection of the Scotland-street Engine Works; but it struck him that instead of reducing the size of the furnace, if the position of the fire had been changed, it would have been found that less of the heat would go up

the chimney. If the flues were extended he believed that little or none of the heat would in that way escape.

The President said Mr. Tait had been working at these experiments for a very long time, and had spent much of his time upon them, and they had cost a considerable sum of money, as all practical experiments did; and therefore he thought the Institution were much indebted to him. He proposed a vote of thanks to Mr. Tait accordingly, which was passed unanimously.

On White Gunpowder.

From the London Chemical News, No. 83.

Dr. J. J. Pohl has improved on Augendre's white gunpowder (*Sitzunsb. du Akad. der Wissenschaft zu Wien.* Bd. xli. s. 634). He prescribes the following quantities:—

Ferrocyanide of potassium,	28 parts.
Cane sugar,	23 "
Chlorate of potash,	49 "
	100

which give a well-burning powder, and nearly approaches the proportions

$$K_2 Fe Cy_3, 3HO + C_{12} H_{11} O_{11} + 3(KO Cl, O_5).$$

The results of the combustion of this mixture he calculates to be,

$$2K Cy + 3K Cl + Fe C_2 + N + 6CO + 6CO_2 + 14HO;$$

or, 100 parts by weight of the powder is resolved into

47·44	gaseous bodies,
52·56	solid residue.
100·00	

The volumes of the gaseous bodies he estimates as follows:—

Nitrogen,	1927·0	cub. centims.
Carbonic oxide,	8942·9	"
Carbonic acid,	8942·9	"
Steam,	20867·6	"
	40680·4	"

Compared with ordinary gunpowder, considered as unity, the results are said to be:—

	Ordinary powder.		White powder.
The volume of gas set free,	1	:	2·107
The temperature of flame,	1	:	0·641
The residue,	1	:	0·77

It should seem, then, that the new powder has over the old the advantages of greater power, igniting at a lower temperature, and leaving less residue. The author points out several other advantages: the ease with which the white powder is manufactured, there being no necessity for granulating and glazing, and the less danger of accidents. The higher price of the materials he considers is more than compensated for by the smaller quantity required.

A political and literary contemporary, who dabbles a little in science, and who describes the above composition as being *equally white and cleanly with common gunpowder*, dismally prophesies innumerable accidents if white gunpowder should ever come into use, in consequence of the explosive nature of chlorate of potash—a danger to which he, with wonderful prescience, says the author has never alluded. As it happens, Dr. Pohl is at pains to show that fears like those of our contemporary are groundless. Only, he states, the heaviest stroke of iron upon iron is sufficient to produce an explosion, and that it is impossible to ignite the powder by rubbing it between wood and metal, or between stones.

The Electric Light.

From the London Mechanics' Magazine, June, 1861.

The experiments with the electric light, which have now been made for a long time past at the Palais-Royal, Paris, are still continued every evening with increasing success. Lately, instead of two burners fed by divided currents from the magneto-electric machine, one burner, fed by a single current, has been used. It is raised sixteen metres, and illuminates, as with the light of the full moon, the whole square in front of the Palais-Royal, and the two entrances of Rue Saint Honoré. Two hyperbolic reflectors—one above the light, the other below—increase and diffuse the light. By certain improvements in the prisms or cylinders of artificial carbon, which are used in the production of the light, M. Curmer is now able to make electric lamps which will burn five or six hours without requiring any attention. The lamp of M. Serrin, placed before the house of Prince Eugene, also burns brilliantly. M. Serrin has succeeded lately in causing his lamp to burn under water almost as well as in the atmosphere. Thus, we may now light the bottoms of rivers, or of the sea, or the bottoms of floating vessels, sunken wrecks, the foundations of piers, and other submarine structures. It is expected that we shall soon be able to apply this method of illumination in our lighthouses, ships, and generally on land in our cities and houses. At the Invalides lately, in the presence of Despretz, Babinet, Foucault, and others, a magneto-electric machine was worked by one of Lenoir's lately-invented gas-engines, of 3-horse power. By this means, a strong electric current was generated, and M. Serrin's lamp gave a very brilliant light, equal to two hundred Carcel burners.

Making of Ice artificially.

In a former number of our *Journal*, we described the apparatus invented by M. Carré, for freezing water by means of the evaporation of ammoniacal gas. Our description was taken from the *Cosmos;* we now take from the same journal the following description of the apparatus established upon a practical scale, and arranged so as to work perpetually.

The generator contains in its lower part, which is called the *boiler*,

190 lbs. of an ammoniacal solution at 28°. Under the action of the heat, the ammoniacal gas is disengaged, and passes into a second compartment which encloses a series of superposed horizontal tubes, with large vertical tubulors in the middle; this set of tubes performs the function of a rectifier; that is, the gaseous ammonia disengaged by the heat comes in contact in these tubes with the liquid returning to the boiler, gives up to it its vapor of water, and passes to a state of almost absolute purity. From the *rectifier*, the gas passes into a worm, and from this to a *liquefier;* a collection of tubes around which is a current of water, at a temperature of from 53° to 59° Fah. On coming out of the liquefier, the ammonia, now liquid, and still pushed on by the pressure in the boiler, which is some ten atmospheres, enters another vessel called the *regulator*, in which floats a bell with very thin metallic walls, which, by its successive risings and fallings, regulates the discharge of the liquid, and prevents the mixture of any bubbles of gas. Thus condensed, the liquid passes through the induction valve into the *refrigerator*, which is a worm wound several times around the cylinders filled with the water to be frozen, which are placed in a vat of an uncongealable liquid, such as a strong alcohol, or, better, a sufficiently saturated solution of *chloride of calcium* (*muriate of lime*).

After resuming the gaseous form, at the expense of the heat of the water in the cylinders, and thus freezing it, the ammonia leaves the worm by a vertical tube, fills a central bottle, and comes into the *absorber*, where it comes into contact with the water exhausted of its ammonia, passing from the bottom of the boiler, and minutely divided by passing through a great number of small holes. There the ammoniacal solution is re-formed, with a disengagement of heat, which is absorbed by circulating again through cold water; finally, from the *absorber*, the ammoniacal solution passes into the boiler by its top, and passes through the tubes of the *rectifier*.

The ice forms very rapidly, and is very solid and opaque; its temperature is about 12° Fah., so that it is not necessary to wait until the water of the cylinders freezes to the centre, as the action goes on after the cylinder is withdrawn. The cylinders are removed every 8 minutes, and the ice of each one weighs about 9 lbs. With an expense of 5·5 lbs. of coal burned, there is obtained 55 lbs. of ice per hour, and this ratio will increase with the capacity of the apparatus; so that when 200 or 2000 lbs. are made per hour, the price of the ice will not exceed $2·25 per ton.—*Cosmos.*

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, September 19, 1861.

John C. Cresson, President, in the chair.
John Agnew, Vice President, } Present.
Isaac B. Garrigues, Recording Secretary, }
The minutes of the last meeting were read and approved.

Donations to the Library were presented by the Chemical Society, of London; la Société d'Encouragement pour l'Industrie Nationale, Paris, and la Société Industrielle de Mulhouse, France; the Osterreichischen Ingenieurs Verienes, and the Néider Osterreichischen Gewerbe Vereines, Vienna, Austria; the Natural History Society of Montreal, Canada; the Mercantile Library Association of the City of Brooklyn, New York; John Warner, Esq., of Pottsville, Penna.; L. Blodget, Esq., Frederick Fraley, Esq., the Councils of the City of Philadelphia, and Profs. J. A. Meigs, J. C. Cresson, and John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of July was read.

The Board of Managers and Standing Committees reported their minutes.

The candidates proposed at the last meeting were duly elected members of the Institute.

Ulric Dahlgren, Esq., exhibited and explained to the meeting the following Photographs, which were viewed with much satisfaction by the members, being of a large size, and well executed works of art. They consisted of:—

A Chinese Fort, at Peiho, captured by the French and English, Aug. 21st, 1860; showing the exterior, where an entrance was forced through a breach in the upper wall by means of scaling ladders, after first breaking down and removing the palisades which had been stuck around the Fort for some distance, with pointed ends, to prevent the approach of an enemy.

Three Interior Views of the same portion of the Fort, in different positions. Here the structure and composition of the wall can be seen, seeming to be of piles interlaced with light fastenings, and then filled out with clay and like substances. There are two tiers of guns, with roads at the angles to reach the upper one. Where the storming party entered, large numbers of the dead Chinese are visible; an English officer being the only one on their side remaining of the dead. These pictures were taken on the spot immediately after the fight; a set of them were obtained and brought over by Lieut. H. A. Wise, U. S. N.

Views of Naval Battery, showing the sailors at their guns ready for firing, and the town of Alexandria, Va., in the back-ground. This battery was sent from the Washington Navy Yard for the protection of Alexandria, and is a portion of the regular naval service. It is considered the finest and most efficient in the field, and is situated on Shuter's Hill.

Views of the Country between Washington and Alexandria, showing the different encampments in the Valley of the Potomac. Washington forms a prominent feature of the back-ground, with the Potomac meandering by it.

The position of Capt. Ward, U. S. N., and his crew, when he was killed. He had sent a party on shore to erect a battery at Mathias Point, on the Potomac River, and, meeting a large party of the enemy, attempted to escape from such superior numbers after nearly all were more or less disabled. Capt. Ward endeavored to drive back the enemy by shelling them from his vessel, the *Freeborn*, and, while in the act of aiming, was struck by a musket ball, and killed. This picture is intended to show the position of all on the vessel at the time, Capt. Ward being represented by a man who resembled him very much, and similarly attired. Being taken on the same vessel, it is a faithful picture.

The Officers of the 71st Regiment N. Y. S. M., as they happened to be together at the Washington Navy Yard, just before leaving for Bull Run, where several of them were killed.

Projectiles used by the Secessionists: 1st, A Shell fired from battery at Acquia Creek, during an engagement with the vessels of the Potomac Flotilla, June 1st, 1861. 2d, Shot fired at Bull Run, July 21st, 1861. 3d, Loaded Shell fired from Munson's Hill, Aug. 9th, 1861. These projectiles were all of an inferior model and make, and did their work imperfectly. The latter fell base first; it was loaded, and had a Boarman fuse in it, but did not explode. The lead on the bottom did not take the grooves of the rifle, and consequently did not have the rotatory motion necessary to keep it straight.

The Sawyer and the Shenkle Projectiles. The former is a shell of iron covered with a soft composition, and with flanches intended to fit the grooves of the rifle instead of having the metal expanded by the force of the powder, and to which latter arrangement it has given way. The peculiarity of the Shenkle projectile is in supplying the place of the soft metal on the base by papier-maché. Both are of an elongated shape, and pointed.

An Infernal Machine, used by the Secessionists. It consists of an iron cylinder, about 6 ft. long and 2 ft. in diameter, and perfectly water-tight. This is filled with 300 lbs. of powder. It is attached by ropes 6 ft. long to an empty hogshead, which supports it in the water, the side of the hogshead being exposed. An elastic tube is fitted water-tight, and connects the interiors of the magazine and barrel; through this tube the fuse runs, which is lighted through an aperture in the exposed side of the hogshead, and which, burning down till it reaches the cylinder, explodes it. The fuse would burn two hours. After being lighted and set loose, it was intended to float with the tide till it reached a vessel, and there remain, finally exploding. It was a very uncertain arrangement. There were two fastened by a rope several hundred feet long, but the other was lost.

These photographs were taken by the Photographer of the Ordnance Department, at the Washington Navy Yard.

METEOROLOGY.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

AUGUST.—The mean temperature of August (73·15°) was a degree and a half lower than the mean for eleven years, and two degrees below that of the same month last year. It was the coldest August on the record for the last eleven years, with the exception of August, 1856, of which the mean temperature was 72·15°.

The warmest day of the month was the 5th, of which the mean temperature was 85·2°. The highest degree of heat indicated by the register thermometer was 94° on the same day.

The coldest day was the 13th with a mean temperature of 62·5°. The thermometer indicated the lowest temperature (54·5°) on the morning of the 14th. The range of temperature for the month was 39·5°.

The greatest change of temperature in the course of a day, was 23·5°, on the 24th; the least was 6·5°, on the 29th. The average oscillation for the month (16·84°) was nearly two degrees less than that for August, 1860, but nearly one degree greater than the average for eleven years.

The greatest daily range of temperature was 12·7 degrees between the 11th and 12th; the least was 0·5 of a degree between the 1st and 2d. The average daily range for the month was 3·94°, which was a little more than the average for eleven years, and but one-tenth of a degree greater than for August, 1860.

The pressure of the atmosphere was greatest (30·212 inches) on the morning of 21st, and least (29·608 inches) on the morning of the 13th of the month. The mean daily pressure was least (29·661 inches) on the 10th, and greatest (30·160 inches) on the 21st. The average pressure for the month (29·906 inches) was greater than for any August since 1855, and was nearly four-hundredths of an inch greater than the average pressure for the last eleven years.

The greatest mean daily range of pressure for the month was 0·325 of an inch, between the 21st and 22d; the least was 0·018 of an inch, between the 7th and 8th; and the average for the whole month was 0·098 of an inch, which is five-thousandths of an inch greater than usual, and seven-hundredths of an inch more than for the same month last year.

The force of vapor and dew-point were greatest on the 5th of the month, and least on the 15th, and both were a little greater than the average for eleven years. The relative humidity was greater than for any August since 1853. It was greatest on the 29th, and least on the 15th and 31st of the month.

Rain fell on twelve days of the month, to the aggregate depth of 2·864 inches. This was nearly six and a half inches less than fell in August of last year; and two inches less than the average amount

for the month. The number of rainy days was greater than usual, though but a small quantity of rain fell at any one time. Rain fell in frequent showers during the 11th, 12th, and 13th days of the month, but during the whole time only an inch and a quarter fell at Philadelphia. It appears from the papers that, during the same days, a very great amount of rain fell in the Northern and Eastern States. The storm commenced with rain and a very strong wind in Chicago, on the 10th, and, passing slowly towards the east, reached Boston on the 13th. Considerable damage was done by the flood and wind in Chicago, Buffalo, southern Ohio, and New York.

There was but one day—the 15th—entirely clear, and the sky was completely covered with clouds at the hours of observation, on five days of the month.

A Comparison of some of the Meteorological Phenomena of August, 1861, *with those of* August, 1860, *and of the same month for eleven years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	Aug. 1861.	Aug. 1860.	Aug. 11 years.
Thermometer.—Highest,	94°	95°	97°
" Lowest,	54·5	55	47
" Daily oscillation,	16 84	18·80	16·02
" Mean daily range,	3·94	3·80	3·78
" Means at 7 A. M.,	68·88	70·13	70·16
" " 2 P. M.,	79·52	82·87	80·63
" " 9 P. M.,	71·05	73·29	73·16
" " for the month,	73·15	75·43	74·65
Barometer.—Highest,	30·212 in.	30·026 in.	30·255 in.
" Lowest,	29·608	29·632	29·356
" Mean daily range,	·098	·090	·093
" Means at 7 A. M.,	29·912	29·848	29·882
" " 2 P. M.,	29·896	29·813	29·855
" " 9 P. M.,	29·910	29·834	29·873
" " for the month,	29·906	29·832	29·870
Force of Vapor.—Means at 7 A. M.,	·602 in.	·580 in.	·586 in.
" " " 2 P. M.,	·608	·584	·597
" " " 9 P. M.,	·612	·603	·613
Relative Humidity.—Means at 7 A. M.,	83 per ct.	78 per ct.	77 per ct.
" " " 2 P. M.,	60	52	57
" " " 9 P. M.,	79	73	74
Rain, amount in inches,	2·864 in.	9·260 in	4·546 in.
No. of days on which rain fell,	12	13	10·4
Prevailing winds—Times in 1000-ths,	s 85°55′ E. ·088	s 80°54′ w ·150	s82° 31′ w ·085

Summer.—The mean temperature of the Summer of 1861 was 74·13°, which was about a degree and a half below that of the Summer of 1860, and about the same amount below the average for ten years. It was the coldest Summer for the last ten years, with the exception of that of 1859, of which the mean temperature was 73·79°.

The warmest day was the 8th of July, of which the mean tempera-